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The Great Nebula in Andromeda.

By J. ELLARD GORE, F.R.A.S., M.R.I.A.

PERHAPS the most remarkable celestial object in the Northern hemisphere is the great nebula in Andromeda, known to astronomers as 31 Messier, and sometimes described as "the queen of the nebulæ." On a clear, moonless night it may be just detected with the naked eye as a hazy spot of light near the 4½ magnitude star, Nu Andromedæ, which lies a few degrees north-east of the well-known "square of Pegasus." It may be well seen with a 3-inch telescope, and even with a good opera-glass or binocular it is a striking and beautiful object. It was probably known to the ancients, and it could hardly have escaped their keen eyesight in the clear Eastern skies. It was certainly seen so far back as A.D. 905. Al-Sufi, the Persian astronomer, who wrote a "Description of the Fixed Stars" in the tenth century, speaks of it as a familiar object in his day (A.D. 964), and it is marked on a star map made in Holland about the same period. It escaped observation, however, by Tycho Brahé and Bayer. Simon Marius described it in 1612 as "resembling a candle shining through horn." Halley explained it as "nothing else but the light coming from an extraordinary great space in the ether, through which a lucid medium is diffused that shines with its own proper lustre"—a not very illuminating hypothesis. A small adjacent nebula a little to the north-west of it was discovered by Le Gentil in November, 1749, and a smaller and nearer one touching the south-east border by Miss Caroline Herschel in 1783. Messier, observing Le Gentil's nebula in 1764, remarked that its position and form had remained constant since its discovery, but observations in recent years have raised some suspicions of change.

In September, 1847, Bond detected two dark rifts running nearly parallel to the longer axis of this great nebula. For many years the meaning of these channels remained a matter of mystery, but a photograph taken by the late Dr. Isaac Roberts in December, 1888, first revealed the true character of the nebula. The "dark rifts" were then seen to represent dark intervals between rings into which the nebula was divided, and the photograph shows the nebula for the first time in a clearly "intelligible form." The nebula appears as an elongated ellipse with a bright central nucleus. Its figure suggests that its real form is that of a circular mass, or, rather, a disc of large diameter, but comparatively small thickness—like Saturn's rings—projected into an elongated ellipse by the high inclination of its plane to the background of the heavens. Judging from other similar nebulæ this is doubtless its true character. It was at first supposed that the photograph showed a ring formation similar to that indicated by Laplace's famous Nebular Hypothesis, but a closer examination of other photographs subsequently taken show that the nebula is really a spiral. Dr. Roberts says, with reference to a photograph taken by him on October 17, 1895, "That the nebula is a left-hand spiral, and not annular, as I at first suspected, cannot now be questioned, for the convolutions can be traced up to the nucleus, which resembles a small bright star at the centre of the dense surrounding nebulosity; but, notwithstanding its density, the divisions between the convolutions are plainly visible on negatives which have had a proper degree of exposure. If we could view the nebula from a point perpendicular to its plane it would appear like some of the other spiral nebulæ . . . and its diameter subtend an angle of about two and one-third degrees; but as we can only view it at an acute angle it has the appearance of an ellipse."

The apparent size of this great nebula shows that it must be an object of vast dimensions. The nearest star to the earth, Alpha Centauri, although probably equal to our sun in volume, or even somewhat larger, certainly does not exceed one-hundredth of a second in diameter. But in the case of the Andromeda nebula we have an object of considerable apparent size, not measured by seconds of arc, or even minutes, but showing an area about three times greater than that of the full moon. The nebula certainly lies in the region of the stars, and its apparently large size shows that it must be of stupendous dimensions. A moment's consideration will show that, whatever its distance may be, the farther it is from the earth the larger it must be in actual size. The sun is much larger than the moon, but its apparent size is the same, owing to its greater distance. Sir William Herschel thought the Andromeda nebula to be "undoubtedly the nearest of all the great nebulæ," and he estimated its distance at 2,000 times the distance of Sirius. This would not, however, indicate a relatively near object, as it would imply a light journey of over 17,000 years!

It has been generally supposed that this great nebula lies at a vast distance from the earth, possibly far beyond most of the stars seen in the same direction; but, perhaps, not so far as Herschel's estimate would imply. Recently, however, Professor Bohlin, of Stockholm, has found from three series of observations made in recent years a parallax of c//.17*. This indicates a distance of 1,213,330 times the sun's distance from the earth, and a "light journey" of about 19 years. This would make the distance of the nebula more than twice the distance of Sirius, about four times the distance of Alpha Centauri, but less than that of Capella.

* *Astronomische Nachrichten*, No. 4213.

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Professor Bohlin's result is rather unexpected and will require confirmation, but it will be interesting to enquire what this parallax implies as to the real dimensions and probable mass of this vast nebula. The extreme length of the nebula may be taken as its diameter considered as circular. For although a circle seen obliquely is foreshortened into an ellipse, still the longer axis of this ellipse will always represent the real diameter of the circle. This may be seen by holding a penny at various angles to the eye. Now, Dr. Roberts found the apparent length of the nebula to be 2½ degrees, or 8,400 seconds of arc. This diameter in seconds divided by the parallax will give the real diameter of the nebula in terms of the sun's distance taken as unity. Now 8,400 divided by 0″.17 gives nearly 50,000, that is, the real diameter of the Andromeda nebula would be, on Bohlin's parallax, nearly 50,000 times the sun's distance from the earth. As light takes about 500 seconds to come from the sun to the earth the above figures imply that light would take no less than 290 days, or over nine months to cross the diameter of this great nebula.

Elementary geometrical considerations will show that if the nebula lies at a greater distance from the earth than that indicated by Bohlin's parallax its real diameter, and, therefore, its volume and mass, will be greater. If, therefore, we assume the parallax found by Bohlin, we will probably find a *minimum* value for the size and mass of this marvellous object.

Among Dr. Roberts' photographs of spiral nebulæ there are some which are apparently seen nearly edgeways and show that these nebulæ are very thin in proportion to their diameter. From a consideration of these photographs we may, I think, assume a thickness of about one-hundredth of the diameter. This would give for the thickness of the Andromeda nebula about 500 times the sun's distance from the earth. This great thickness will give some idea of the vast proportions of the object we are dealing with. The size of the whole Solar System—large as it is—is quite insignificant in comparison. The diameter and thickness found above can easily be converted into miles, and from these dimensions the actual volume of the nebula can be compared with that of the sun. It is merely a question of simple mensuration, and no problem of "high mathematics" is involved. Making the necessary calculations I find that the volume of the Andromeda nebula would be about 2.32 trillion times (2.32×10^{18}) the sun's volume; that is, 232 followed by 16 cyphers. Assuming that the nebulous matter fills only one-half of the apparent volume of the nebula, we have the volume $= 1.16 \times 10^{18}$. If the nebula had the same density as the sun, this would represent its mass in terms of the sun's mass taken as unity, a mass probably far exceeding the combined mass of all the stars visible in the largest telescopes! But this assumption is, of course, inadmissible, as the sun is evidently quite opaque, whereas the nebula is, partially at least, more or less transparent. Let us suppose that the nebula has a *mean* density equal to that of ordinary atmospheric air. As water is about 773 times heavier than air and the sun's density is 1.4 (water = 1), we have the mass of the nebula equal to 1.16×10^{18} divided by 773×1.4, or about 10^{15} times the sun's mass, which is still much greater than the probable combined mass of all the visible stars. As it seems unreasonable to suppose that the mass of an individual number of our sidereal system should exceed the combined mass of the remainder of the system, we seem compelled to further reduce the density of the Andromeda nebula. Let us assume a mean density of, say, the millionth of the density of hydrogen gas, which is about 14.44 times lighter than air, and we obtain a mass of about 8×10^7, or 80 million times the mass of the sun, which is still an enormous mass.

As possibly I may have assumed too great a thickness for the nebula, let us take a thickness of one-tenth of that used in the above computations, or one-thousandth of the length of the nebula. This gives a mass of eight million times the sun's mass. This seems a more probable mass, if the nebula is—as Bohlin's parallax implies—a member of our sidereal system.

If we assume a parallax of, say, 0″.01, or one-hundredth of a second of arc—which would still keep the nebula within the bounds of our sidereal system—we have the dimensions of the nebula ten times greater, and hence its mass a thousand times greater (10^3) than that found above. The mass would then be eight thousand million times the mass of the sun! This result seems highly improbable, for even this small parallax would imply a "light journey" of only 326 years, whereas the distance of the outer portions of the Milky Way has been estimated by Professor Newcomb at 3,000 years' journey for light.

In Dr. Roberts' photograph many small stars are seen scattered over the surface of the nebula; but these do not seem to me quite so numerous as in the surrounding sky. If the nebula lies nearer to us than the fainter stars visible on the photograph, some of these may be obscured by the denser portions of the nebula; some may be visible through the openings between the spiral branches; some may lie in the nebula itself; while others may be actually nearer to us and are simply projected on the nebula.

To add to the difficulty of solving this celestial enigma the spectroscope shows that the Andromeda nebula is not wholly gaseous. The spectrum is continuous and, according to Scheiner, is very similar to the solar spectrum, and "the greater part of the stars composing the nucleus of the nebula belong to the second spectral class." He thinks that the nebula "is now in an advanced stage of development. No trace of bright nebular lines are present, so that the interstellar space in the Andromeda nebula, just as in our stellar system, is not appreciably occupied by gaseous matter." He suggests that the inner part of the nebula "corresponds to the complex of those stars which do not belong to the Milky Way, while the latter corresponds to the spirals of the Andromeda nebula." The difficulty of reconciling this view of the nebula with its supposed small density is obvious. We may, however, consider that the component particles are small and very widely separated, and in this way its *mean* density might be very small indeed.

It has been suggested that possibly the Andromeda nebula may be an "external universe," that is, a universe entirely outside our sidereal system, and comparable with it in size. Let us examine the probability of such an hypothesis. Assuming that the nebula has the same diameter as the Milky Way, or about 6,000 "light years," as estimated by Newcomb, I find that its distance from the earth would be about 150,000 light years. As this is about 8,000 times the distance indicated by Bohlin's parallax, its diameter would be 8,000 times as great, and hence its volume and mass would be 8,000 cubed, or 512,000,000,000 times greater than that found above; that is, about four trillion times (4×10^{18}) the sun's mass! As this seems to be an incredibly large mass to be compressed into a volume of the size of our sidereal system, we seem compelled to reject the hypothesis that the nebula can represent

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an external universe. The sun placed at the distance corresponding to 150,000 light years would, I find, shine as a star of less than the 23rd magnitude, a magnitude which would be invisible in the largest telescope which man could ever construct. But the combined light of four trillions of stars of even the 23rd magnitude would be equal to one of 23½ magnitudes above the zero magnitude, or not very much inferior to our sun in brightness. As the nebula shines only as a star of about the 5th magnitude, the hypothesis of an external universe seems to be untenable.

It is evident, however, that the mass of the Andromeda must be enormous, and if it belongs to our sidereal system, and if the other great nebulæ have similar masses, it seems quite possible that the mass of the *visible* universe may much exceed that of the visible *stars*, and may be equal to 1,000 million times the sun's mass—as supposed by Lord Kelvin—or even much more.

In August, 1885, a star of about the 7th magnitude blazed out close to the nucleus of the Andromeda nebula. The new star was independently discovered by several observers towards the end of August. It was not visible to Temple at the Florence Observatory on August 15 and 16, but is said to have been seen on August 17 by M. Ludovic Gully. It was, however, certainly seen by Mr. T. W. Ward at Belfast, Ireland, on August 19 at 11 p.m., when he estimated it 9½ magnitude, and it was independently detected by M. Lajoye on August 30, by Dr. Hartwig at Dorpat on August 31, and by Mr G. T. Davis at Theale, near Reading, on September 1. On September 3 the star was observed as 7½ magnitude at Dun Echt Observatory by Lord Crawford and Dr. Copeland, and its spectrum was found to be "fairly continuous." On September 4, Mr. Maunder, at the Greenwich Observatory, found the spectrum "of precisely the same character as that of the nebula, *i.e.*, it was perfectly continuous, no lines, either bright or dark, being visible, and the red end was wanting." Dr. Huggins, however, on September 9, thought he could see some bright lines in its spectrum. The star gradually faded away, and on February 7, 1886, was estimated only 16th magnitude with the 26-inch refractor of the Washington Observatory. From a series of measures made by Professor Asaph Hall he found "no certain indications of parallax." Professor Seeliger has investigated the decrease in the light of this star on the hypothesis that it was a cooling body which had been suddenly raised to an intense heat by the shock of a collision, and finds a fair agreement between theory and observation. Professor Auwers points out the similarity between this outburst and the new star of 1860, which appeared in the cluster 80 Messier, and thinks it very probable that both phenomena were due to physical changes in the nebulæ in which they occurred.

The appearance of this temporary star in the Andromeda nebula seems to be further evidence against the hypothesis of the nebula being an "external universe." For, as I have shown above, our sun placed at a distance of 150,000 light years would shine only as a star of the 23rd magnitude, or over 15 magnitudes fainter than the temporary star. This would imply that the star shone with a brightness of over a million times that of the sun, and would, of course, indicate a body of enormous size. But the rapid fading away of its light would, on the contrary, imply a body of comparatively small size. We must, therefore, conclude that the nebula, whatever it may be, is not an external universe, but probably forms a member of our sidereal system.

On the Inter-Relation of Scientific Studies.*

By PROFESSOR F. W. OLIVER, F.R.S.

I SHOULD like to explain that I should have been happier if the Committee had asked me to inaugurate the work of this Society in some other way than by a Presidential Address. Once before, only, has it fallen to my lot to deliver a Presidential Address, and this did not diminish the burdens of life—that is, not till it happily fell into oblivion. There would not be so much to grumble about, perhaps, were this Society a going concern; one could then have taken one's cue from one's predecessor in office, or from the fortunes of the Society itself. Being left to my own devices, I take refuge in the group of studies with which it is intended we shall become identified, viz., the natural sciences, with especial reference to biology and geology.

Now, one of the functions which this Society should fulfil is the tardy repair of an omission in the history of the development of this College. If you turn to the archives which record the foundation of the College, 80 years ago, you will find that it sprang into existence fully equipped with separate departments in all the subjects represented in this Society. The College was stocked by a stroke of the pen with experts in every branch of arts, and science, and medicine, worth considering, and it can hardly be doubted that its founders were applauded for initiating a liberal policy much in advance of the times.

In this respect our history has been rather unique. Whilst in most other Universities and Colleges the sciences have separated out from synthetic or collective precursors known as natural philosophy and natural history, with us zoology, botany, and geology have been distinct from the beginning. In my early days the stage of evolution had already been reached at which geology had broken away, but the two biological sciences still hung together. This was far from a satisfactory system, as it worked out, especially where botany was concerned. For the holders of chairs of Natural History were mainly zoologists, and they kept the heel on our neck. The chains of our bondage are now loosed, it is true, but there still remains a certain residuum of the old prejudice in some quarters. To take a concrete example; just suppose a botanist were to be appointed Director of the Natural History Museum! Why, a great many well-meaning people would at once write indignant protests to the *Times*. The truth is, the position of any science in the general regard at the present time depends more than anything else on the character of its exponents in the time of our grandparents. And what is true of botany applies equally to a doctor's practice, a wine merchant's business, or the relation of the classics to a general education. A recognised position may be difficult enough to attain, but once reached it is far more difficult to lose.

But to return to my point. Though in some respects we may have profited from the enlightened policy of our founders, in others we have suffered and still suffer. For in the lack of a common development and upbringing, which alone can establish a definite tradition, there is always the fear of imperfect solidarity between the several departments, the fear that it may be taken for granted that the subjects are distinct when really they are only branches of one great study.

*Being the Inaugural Address given before the Natural Sciences Society, University College, London, Feb. 4, 1908.

To a certain extent this defect has been mitigated in our case, owing to the presence of one great teacher. From 1874 to 1891, Ray Lankester held our Chair of Zoology. The breadth of his teaching is not likely to fade from the minds of those who came under his influence. He was a *naturalist* first, and a zoologist afterwards. By the largeness of his outlook, the clearness of his mind, the force and lucidity of his utterances, and the charm of his personality, he proved himself one of the greatest teachers who have been at any time connected with this College. It has always seemed to me a pity that the restless spirit within him should have led Lankester away from this place, where his genius found so much response. Among the services he rendered was the consolidation of the biological sciences, the establishment of something analogous to that common tradition to which I have just referred.

One great service which a Society like ours can render is to make familiar to those of its members who are specially attached to any given branch the particular problems that are uppermost in allied branches, and also the diversity in points of view and attitude of mind obtaining as regards the same sets of facts among geologists, zoologists, and so on. I wonder whether the reasons have been brought to the notice of geologists why the study of fossil plants has come so prominently into fashion during the last 10 or 15 years, and why it is pursued so vigorously in this country? I wonder if zoologists appreciate that a great series of plant-types, reconstructed from the fossils of various horizons, are now coming into view, which seem to afford a general continuity or evolutionary series leading from a relatively primitive type of life to the higher seed plants of the flora of to-day? It is perfectly evident, I think, that plants and animals must have been as closely inter-related at all stages of their evolutionary history as they are at the present day, for the vegetation must always have served as the means of subsistence of the contemporary fauna. To appreciate how close are these relations, you have only to think of the innumerable reciprocal adaptations between the two kingdoms, of which insects and flowers, and insects and gall-structures, afford the most familiar examples. It will, I think, be generally conceded that such questions offer common ground for the investigations of both zoologists and botanists.

Let me illustrate what I am saying by reference to a particular case.

In the palæozoic rocks of coal-measure age we get very primitive seed plants—broadly, gymnosperms—in which the collecting apparatus in which the pollen is stored (the pollen-chamber) to fertilise the ovule is so abundantly charged with pollen that one is inclined to suspect that this is not merely the result of wind-transport, but that some agent of precision, like an insect-visitor, has been mixed up in the affair. However that may have been, when we get to the Jurassic rocks we come to plants which have, in addition to seeds, accessory parts, like the perianths of modern angiosperms. Here, again, was the evolution of the flower, for that is what we have now reached, connected in any way with insect visits? Information about the insects of the appropriate horizons is very inaccessible; what is required is further elucidation and research into the matter by a competent entomologist. For it is a matter of considerable importance to know, in blocking out the directions of evolution in these plants and understanding their significance, whether we can assume with confidence that they were exposed to an environment of flower-seeking insects.

By himself, a botanist cannot carry the thing beyond the stage of interesting conjecture. The entomologist, on his part, merely publishes a list of insects that have come to light, but the two together, working hand in hand, may, perhaps, contribute in their conjoint results something of very genuine and permanent biological value.

It is quite immaterial to my argument whether the special case cited lead to positive or negative results, for there are thousands of other examples that would have answered the purpose equally well. But I think it must be clear that when you get a zoologist and a botanist working together at the same biological enquiry the results will be likely to appreciate in value on this account not arithmetically, but geometrically.

And if there is much work which rightly claims the joint attention of zoologists and botanists, so, too, there is a large common field for the biologist and geologist.

I think probably in our heart of hearts we are all rather envious of the geologist. His subject matter includes everything from nebula to man, and has innumerable points of contact with all the other sciences. The theatre of his work takes him to the pleasant places of the earth, and, unlike the biologist, he has had the wisdom and the strength to resist the forces that would contract his spirit to the confines of a laboratory. As an outsider, I detect only one cloud on a horizon otherwise serene, and that is the popularity which geology is rapidly acquiring as an examination subject.

Everything relating to the structure and development of the crust of the earth has an interest for the biologist, for it deals with the conditions under which life was pursued in the remote past. If botanists and zoologists have appropriated to themselves the interpretation and re-construction of the fossils—the treasure trove of the geologist—they must always depend upon him for a realisation of the climate and other physical conditions under which those organisms flourished. Without this sort of assistance all our speculations as to function are vain. To take the example of the pollen-chamber, just mentioned. What were the conditions that determined the ascendency of seed plants as opposed to the cryptogamic plants from which they sprang? Two distinct and more or less mutually exclusive views have been taken. According to the one, the pollen-chamber of the ovule into which the pollen-grains were received previous to fertilisation had its main significance as a retreat where the pollen could fulfil its destiny in security from the torrential rains of earlier palæozoic times; according to the other the pollen-chamber was really a water-bath in which the conditions for fertilisation could be regulated in times of drought. It is evident that the botanist is unable to reach a decision in questions of this kind without the good offices of the geologist.

In return, it is possible occasions may arise when the debt can be repaid. The subject of the sculpture of the surface of the earth's crust belongs generally to the province of the geologist, but it is sometimes overlooked that an extremely important factor in this connection is the vegetation-covering with which the surface is clothed. This covering, like a coat of paint, has an immense value as a protective agent against weathering, but, in addition to this, it acts as a constructive agent in organising into soils and eventually rocks the unit particles as they are drifted by wind or water. The sand-dune, of course, is a good illustration of what I mean—mere sand, blown hither and thither, has, I take it, a very different significance, from a topographical and geological point of view, from true

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sand-hills organised and bound by an appropriate vegetation. I have said sufficient, perhaps, to indicate that there is a very promising borderland inviting the common occupation of botanists and geologists.

The infusion of the physiologists' point of view into all biological questions is of the most fundamental importance if our work is not to be sterile. Of what use is it to compare different animals and plants, or their parts, unless we are informed of their functions? An organism is a complex machine in which structure is the expression of function, and unless this is recognised and acted upon it is impossible to establish our conclusions. The problems of chemistry and physics are relatively simple as compared with those of biology, and it is the aim of the physiologist to interpret the phenomena of biology as far as possible in terms of those sciences. That is to say, to express the more complex in the simplest possible terms. Everyone is aware that the ordinary green plant elaborates its body out of the simple inorganic materials available in the soil and air, but no one, so far as I am aware, has yet succeeded in tracing the whole chain of chemical and physical processes, step by step, that are entailed in the production in the plant of any complex product whatsoever.

As time goes on, I suspect these studies will receive a great impetus from economic causes. "Necessity is the mother of invention," and this should hold good in the present case. For already the chemist has discovered the way to synthesize a certain number of the products of plants which have a commercial value and are in general request. This is the case, for example, with indigo, and there must be many more to come. Now the artificial production of indigo threatens to render superfluous the whole industry of indigo-plant-planter. He may either retire as gracefully as the embarrassing circumstances permit, or try to produce his indigo at a lower cost. He will doubtless select the latter alternative, in view of the capital invested in the undertaking. His first care will be to eliminate all waste in the various processes, but he will have to do more than this. To increase the output of indigo per plant he will try and improve the stock, and this he is already doing. An agricultural expert who is investigating the problem in India told me a few months ago that they had already succeeded in raising the yield by a considerable percentage, and he also told me of a curious and unforeseen result—the seeds of the improved breed would not germinate in the ordinary way on account of the excessive hardness of the shells, and he had found it necessary to give them a bath in sulphuric acid, previous to sowing, before a crop could be raised. I only mention this to illustrate what unexpected things are liable to happen when you begin tampering with complicated organisms like plants.

As time goes on the chemist will doubtless threaten other great agricultural interests in the same way. From our standpoint this advance in synthetic chemistry should be exceedingly interesting, for it will act as a stimulus to the prosecution of investigations in plant physiology and in plant breeding on a gigantic scale.

For the struggle will take the form of a contest between agriculture and manufacture, *i.e.*, between the relative efficiency of the plant as a machine for producing this or that a product, and that of a chemically-directed factory.

The agriculturist seems to have two strings to his bow. He may, by breeding and selection, get races of plants giving an enormously increased output—somewhat on the lines that have been followed in improving the sugar-beet—or, by the application of the methods to which such prominent attention has recently been drawn by Professor Bottomley, by stimulating his crops by the addition to the soil of appropriate bacterial or fungal agents, he may compel the plant—under forced draft—to an undreamt-of activity.

Be the result what it may, it is hardly likely that such a struggle will be undertaken without our knowledge of the physiology of plant-processes advancing by leaps and bounds. And, of course, the better fitted the chemist becomes to carry invasion into the territory of the botanist, the better fitted will the botanist be found to repel the attack.

Allusion has been made to methods by which the natural processes of the plant can be stimulated to greater activity by the presence of bacteria in the soil. As attention is again being generally directed to these methods, I think more than a passing reference is appropriate.

Of all the food-substances of a plant, nitrogen has proved the most difficult to obtain, and is commercially the most expensive. All ordinary green plants demand their nitrogen in the combined form as nitric acid, and are unable to utilise the abundant stores of free nitrogen of the air. But there are one or two exceptions, of which the best known is the family of the *Leguminosæ*.

It has long been recognised that Leguminous crops do not impoverish the soil of its nitrates, but, rather, add to their amount; and the cultivation of such crops is resorted to as an expedient for enriching impoverished soils.

About 25 years ago it was discovered that this unique property depended upon the presence of tubercles upon the roots of these plants.

If tubercles were absent, Leguminous plants lacked this peculiar virtue, and according to their abundance they possessed it.

Further investigation showed that the tubercles depended upon the invasion of the quite young roots by a bacterium which has received the name of *Rhizobium*—a bacterium which generally lives in the soil.

So that the nitrogen-fixing property is traceable to the stimulating action of a bacterium upon the green plant.

It was recognised that it was desirable to promote the presence of this useful little organism in soils, and especially poor soils, in which Leguminous crops were to be raised.

With this object, some ten years ago a fertiliser was put on the market by German agricultural experts. It was known as *Nitragin*, and consisted essentially of a powder—the dried bacterial culture in an appropriate medium.

It was found, however, that Nitragin failed in practice to realise anticipations, and it was withdrawn.

In recent years American experimenters have taken the matter in hand, and they, I think it was, who discovered that if you want the bacterium to attack the roots properly, so as thoroughly to inoculate them with tubercles, the bacterium must be sent out in a starving condition. Under these conditions it is found to be much more virulent.

Like the Germans, the Americans put a fertiliser into circulation, and samples reached this country. Experiment showed, however, that the results were very disappointing, and people thought it was merely a revival of the old Nitragin.

A little while ago these cultures came under the notice of Professor Bottomley, who, by a happy inspiration, realised that the loss of virtue in the

bacterial cultures could be remedied if the Rhizobium were cultivated up to its natural resting phase—the sporing condition—and distributed in this form.

The new inoculations which he then circulated were both virulent and retained the power of germinating almost indefinitely. In practice they have given the best results, often leading to a striking increase in the nitrogenous stores of beans and peas.

Professor Bottomley had also been experimenting in another direction. First he showed that the Rhizobium appropriate to particular species of Leguminous plants could be caused to attack other species.

He went further and showed that the bacillus of certain other tubercle-bearing families (of which the Alder and Elæagnus were chosen as representative) could, by taking precautions, successfully be inoculated upon the roots of Leguminous plants. Thus it appeared that the differences generally found between the bacteria associated with the roots of quite distinct groups of plants were purely physiological, and that interchange was possible if the microbe were gradually educated to the new environment.

These results led Professor Bottomley to try whether it might not be feasible to get similar results on plants normally destitute of tubercles. Such plants as oats and barley and tomatoes have been experimented upon, and the results are described as very promising. If Professor Bottomley is able to establish scientifically the liability of any plant to bacterial inoculation and stimulation, it is evident that an entirely new field in agricultural amelioration will be opened up, with results which we can hardly foresee.

The great merit of Professor Bottomley's work arises not merely from the intelligent way in which he has grappled with the practical difficulties, but also in his prompt realisation of the possibilities latent in the inoculation method. His further results will be awaited with considerable interest.

So far, I have endeavoured to show that there is a great deal of common ground in all the natural sciences of which we take cognisance, and that among them are to be found innumerable borderlands and hinterlands whose occupation is debatable.

Those who would embark on borderland studies need to make sacrifices in the way of equipment. For not merely must they be masters in their own field, but they must be prepared sympathetically to consider everything they may find when they have crossed the frontier. No crude incursion like the "Jameson Raid" is of any use here.

The passage from chemistry to botany finds happy illustration in the case of two Englishmen who have done much in recent years to elucidate various aspects of the complex mechanism of photo-synthesis. Both were already qualified by study and investigation in chemistry before ever they turned their attention at all seriously to botany. Though both regarded botany as an extension of the chemical field, and came equipped in this sense, this did not prevent them assimilating current botanical conceptions. The results that have accrued are of fundamental importance and include researches that are likely to become classic. One curious outcome of this double migration is that the world in its rough fashion classifies one of these investigators as a chemist and the other as a botanist—though I doubt if there be any essential difference of attitude to justify such a distinction!

There is always a tendency in any branch of science left too much to itself for points of view to become stereotyped. After a period of active advance a reaction sets in and there is stagnation. Some people profess to think that the field is worked out, but the falsity of this supposition is at once apparent directly a group of new ideas comes to the surface.

Our modern organisation of science is not free from the risk of the different branches becoming isolated like a system of water-tight compartments, and there is much in our methods of education and early specialisation that calls for serious consideration.

The more it is possible to bring the subject matter and current problems of one branch under the notice of those engaged in other fields, the better. This, doubtless, was one of the objects for which magazines like "Science Progress" was founded, and this is the kind of purpose which our University College Natural Sciences Society should serve.

Too often new ideas and what are really very genuine advances fall still-born because they are not offered in acceptable form and lack the conventional garnishings to which we are accustomed. If you are unintelligible you will be ignored, even if you are an archangel from heaven. Where new ideas are concerned the difficult problem has to be solved of bringing the new wine in old bottles, until we have drunk of it.

No doubt our studies are getting terribly specialised; I mean the lines along which a man pursues his work. One realises, of course, that specialisation is inherent in the advance that has taken place, and one looks for a broader general education to mitigate its contracting influence. The *raison d'être* of an almost exclusive devotion to some particular line lies in the tacit assumption that the subject is studied from every point of view. Specialisation should be an edifice raised on a very sure foundation, but I confess that the indications that the general training that precedes a career in science to-day is either more liberal or more thorough than a quarter of a century ago are not altogether reassuring. The matter is one of no little importance, particularly in view of the increasing inducements for the pursuit of a scientific career.

In drawing these remarks to a close, the least I can do is to ask your indulgence for occupying your time with all this grumbling—which I shall not attempt further to justify. As to our meetings and discussions, I venture to express the hope that prominence may be given from time to time to groups of small papers and exhibits dealing with broad topics from different points of view. So far as my experience goes the value of a paper has no relation to its length; more often than not it is from quite modest communications that animated discussions arise.

It is almost superfluous to add that the success of a Society like this depends more on the active participation in its proceedings of the majority of its membership than upon anything else.

Obituary.

IT is with the deepest regret that we have to record the death of Mr. W. A. Shenstone, F.R.S. Mr. Shenstone had been struggling with indifferent health for some time past, but his death at the comparatively early age of fifty-eight was a painful shock to his many friends. Mr. Shenstone, who had been Science Master at Clifton College for more than a quarter of a century, was best known, apart from his chemical researches, for his interest in the movements relating to the teaching of science and to its place in examinations; and for two years he was Honorary Secretary of the Public Schools Science Masters' Association. His death is a severe loss to the cause of the exposition of science and the development of the scientific spirit in education. To those who knew him it is the loss also of a nature and disposition of the greatest sweetness, kindness, and modesty.

XUM

Some Insoluble Geometrical Problems.

By THOMAS H. BLAKESLEY.

THE rectification of the circular arc, and the inverse problem, the construction of an angle when the ratio of the arc to the radius is furnished, are considered insoluble by the ordinary processes of Euclid. This is true only if the number of applications of such processes is limited. It may interest some readers to consider two instances, referring to the above-mentioned problems, in which the process is so rapidly convergent that the applications need not be frequent, though in theory they are infinite.

Suppose (Fig. 1) AOZ is a given angle, and that it

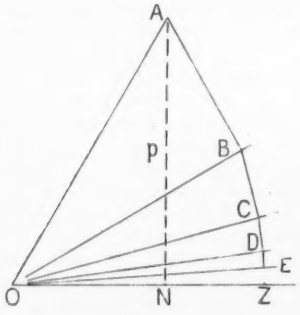


Fig. 1.

is desired to represent its circular measure by the ratio of two *straight* lines.

(1) Bisect the angle by OB, and drop AB, a perpendicular upon it.

(2) Bisect the angle BOZ by OC, and drop BC, a perpendicular upon it.

(3) Continue this process, always bisecting the angle which remains between the last bisector and OZ, and dropping the new perpendicular from the foot of the last one.

It is clear that very soon the remaining angle disappears, and the point Z, upon OZ, will be reached, which will not move sensibly for any further steps in the process.

Finally, from A, drop a perpendicular upon OZ, and call it p.

Then $\frac{p}{OZ}$ is the circular measure of the given angle.

The inverse problem.—When the circular measure θ, is given, to construct the angle.

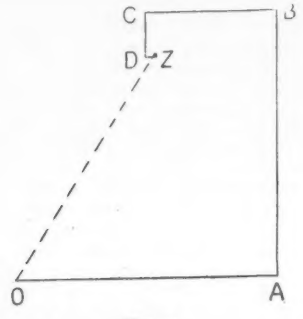


Fig. 2.

In Figure 2, take a line OA as unity, and draw AB perpendicular to it, and of length θ.OA. Draw BC perpendicular to AB (the right angle being taken in the same sense as before) and equal to $\frac{\theta.AB}{2}$.

Similarly CD is perpendicular to BC, and equal to $\frac{\theta.BC}{3}$, and so on.

Here, again, the final point Z is rapidly approached, and if OZ be joined, it will be equal to OA, and AOZ is the angle whose circular measure is θ.

The case drawn in the figure is that of the radian, where $\theta = 1$.

The second problem was communicated to me in exchange for the first, by Mr. W. A. Price.

A Storm Cloud.

LIEUT.-COL. C. T. PETERS, M.B., writes to us from Bombay as follows:—"I am enclosing a photograph taken in April last, showing a storm-cloud which rapidly rose above the horizon in the east. After having taken a snapshot of it, it rose up to about 45°, and I had just time to get under

Photograph of Storm-Cloud.

the shelter of my verandah as a heavy shower of rain came down.

It was taken in Dinajpur, North Bengal, about Long. 26° N., and Lat. 88° E., at about 3 or 4 in the afternoon. With a magnifying glass, the rain drops were visible in the photograph at the lower strata of the *cirro-cumuli*."

A Portable Sundial for Indicating Legal Time.

By DR. ALFRED GRADENWITZ.

WHEREAS sundials once upon a time were the most important means of ascertaining the approximate or accurate time, they have lost at present all practical value, serving only now and then for the purpose of decoration. This decay is due on the one hand to the

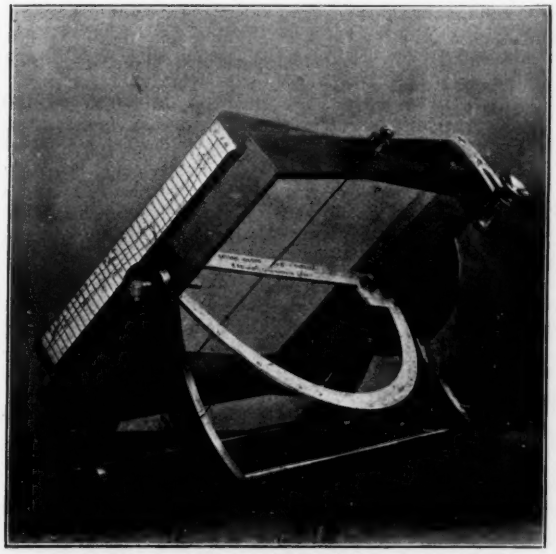


Fig. 1. The Sundial.

improved watch construction, and on the other to the introduction of mean or *legal time* in the place of *real time*; the difference between these two times is known to vary from day to day according to what is called the "equation of time." In order to derive the legal time from the reading of a sundial, a calculation has therefore to be made, which, though not complicated, is rather inconvenient, if not impossible to the general public. Furthermore, most countries have introduced lately throughout the whole of their territory standard time (*e.g.*, middle-European time in the centre of Europe), which is obtained from the mean local time by means of a correction dependent on the geographical longitude of the place.

In spite of these obvious drawbacks to the use of sundials, it is a matter of regret that this excellent means of checking the working of a clock should have been so entirely abandoned, and the recent endeavours of a French scientist, Vicomte d'Aurelle Montmorin, to adapt it to the requirements of modern times should, therefore, be welcomed.

The portable sundial constructed by him will immediately give legal time or standard time if its adjustment be altered from day to day by some slight amount derived from a curve attached to the apparatus.

The equatorial dial, which forms the main part of the apparatus, consists of a thin wire and a semi-circle, provided with a scale of time with divisions of five minutes each, and the centre of which is situated in the wire. This is fixed to a system of two rectangular frames which are free to rotate round two perpendicular axles.

One of these axles is horizontal, and serves to adjust the wire by means of a special scale according to the inclination of the axis of the earth. The other axle coincides with the axle of the wire, and serves to impart to the scale of time the angular displacement corresponding to the equation of time. This displacement is controlled by means of the following devices.

One of the edges of the outside frame is bevelled, and constitutes a line accurately parallel to the wire. The same is true of a reference line determined by two marks engraved into the adjoining surface of the inside frame. To this inside surface is applied a small ruler, on which two curves (Figs. 2 and 3) representing the equation of time for each day of the year, have been traced, one curve being characteristic of the first, and the other of the second half of the year. The vertical distances of these curves from the horizontal middle axis (that is, the ordinates) will give the departure of legal time from real time corresponding to each day.

The ends of the ruler are finally provided with two scales in time minutes, which serve for obtaining the correction of longitude for passing from legal time to standard time. In order to effect this correction, the division corresponding to the geographical longitude of the place should be placed in front of the mark above referred to.

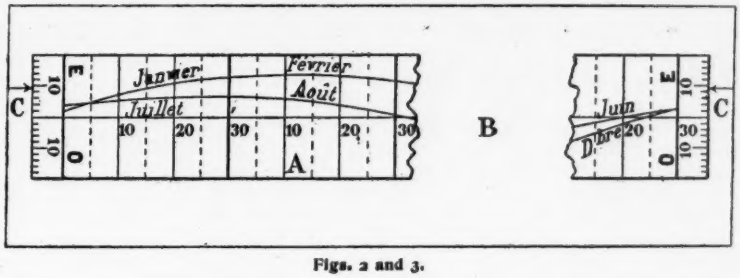
It is obviously quite sufficient to effect the correction of longitude once for all, while the correction corresponding to the equation of time should be made every two or three days.

The apparatus above described is not destined to be an instrument of precision lending itself to the checking of astronomical chronometers, but rather a practical device suitable for the purposes of lay people. The accuracy warranted by the instrument accordingly corresponds to the requirements of the general public, amounting to a minimum of a minute.

According to a suggestion of the inventor, this device could be supplemented so as to become a real sun clock. To this effect the wire should be replaced by a narrow slot and a small selenium wire communicating with the battery, and an electric bell should be fixed on each division corresponding to an hour.

If, now, the whole apparatus be surrounded by a casing, so as to cause the sunbeams to penetrate only through the narrow slot, the electric bell will be rung whenever the sunbeams strike a selenium wire, thus signalling each hour. Half-hours could be signalled by means of another bell of different timbre.

If, then, the knob of a repetition clock be actuated by the current traversing the selenium wire, the clock could be made to repeat the hours at the very moment the sunbeams are striking the selenium wire, provided the clock be advancing somewhat.



Figs. 2 and 3.

Photography: Pure and Applied.

By CHAPMAN JONES, F.I.C., F.C.S., &c.

The Action on Plates at a Distance in the Dark.

IT is well known that many substances, such as bright metals, paper, wood, printers' ink, hydrogen peroxide, and so on, when placed near, though not in actual contact with, an ordinary gelatine plate, will convert the silver bromide therein into the developable condition. Obviously the effect must result from the action of something that comes away from the active material, but whether this is the vapour of the material itself, whether it is produced by the action of the material on the atmosphere surrounding it, or whether it is a form of radiant energy, is not very easy to decide. Perhaps the immediately active substance is not always the same. An important contribution to this subject has recently been published by Elizabeth Légrády (*Zeit. Wissen. Phot.*), who comes to the conclusion that, at least when metals are employed, ionised hydrogen is produced and that it is this that effects the change in the silver salt, though how it acts she does not venture to suggest.

She used a light-tight and air-tight vessel so that the experiments could be carried on in any desired gas. The method was to support a newly-polished and bright piece of the metal between two photographic plates, one above and one below, both with their films turned towards the metal and separated 2 mm. from it by interposed glass rods. Dry air, dry hydrogen, and dry nitrogen, acting for several hours, produced no change in the plates in the absence of metals. With either aluminium, cadmium, copper, magnesium, or zinc, arranged as described, twelve hours in either dry nitrogen or dry air gave not the slightest trace of an image on development. Therefore the investigator concludes that the effect in question is not due to radiant energy nor to the vapours of the metals. With purified moist air, magnesium gave a good image, and zinc and cadmium weaker but still decided images. Moist nitrogen gave a much greater effect with all the metals, except copper. Hydrogen dry or moist gave a still stronger effect, but copper remained inert. Thus it is hardly possible that hydrogen peroxide can be the common cause of the action on the plates, as neither oxygen nor water is essential for it.

In order to eliminate still more stringently any elements of uncertainty as to the conditions under which the results were obtained, a smaller box was made, and everything was much more carefully dried by means of phosphoric anhydride. Under these conditions pure dry hydrogen gave with either zinc or cadmium a good strong image. Therefore the investigator concludes that, as hydrogen itself is inert, the active agent must be hydrogen changed by the metal—ionised hydrogen. This inference was confirmed by means of platinum black, which, in air, does not affect the plate, but in an atmosphere of hydrogen gave, in six hours, a good black image on development. In an atmosphere of nitrogen with such an arrangement as that described, some metals so affect either one or both of the sensitive plates as to render the silver salt less easily developable than otherwise, causing the part affected to remain undarkened while the rest of the plate fogs. Aluminium, magnesium, nickel, and zinc give a dark image on both the upper and the lower plate. Silver, cadmium, manganese, and lead give a dark image on the upper and a light image on the lower plate. Bismuth, chromium, antimony, selenium, and tin do not affect the upper plate and give a light image on the lower. Cobalt gives a dark image on the upper and no effect on the lower plate; while gold, copper, iron, platinum, and mercury affect neither.

Although several investigators have worked at this problem, our knowledge seems hardly full enough as yet to form theories of the action, except, of course, those tentative hypotheses that are necessary as suggestions of lines along which to pursue research. There are facts that indicate that the effect is not due merely to the evolution of a substance that diffuses into the intervening medium. The action of certain mercury compounds under similar conditions has recently been investigated and will form the subject of a note in the next issue of this journal.

The Reversing Action of Red and Infra-red.

That the red and infra-red of the spectrum tend to cause reversal of the developable image is well known, and it is interesting to note that they also tend to quench (or reverse) phosphorescence, which is itself caused, like the developable condition of silver salts, by light of shorter wave-length. Messrs. Nichols and Merritt find that the less refrangible light has this effect whether it is allowed to impinge on the phosphorescent material before, during, or after its excitation. When the phosphorescence is decaying a sudden drop in its intensity is noticed immediately the light of longer wave-length falls on the phosphorescent surface.

The Persulphate Reducer.

Mr. H. W. Bennett, some little time ago, stated that the addition of sulphuric acid and a sulphite to the solution of ammonium persulphate produced a solution that acted more regularly than the persulphate alone, and that the solution would keep in usable condition for a considerable time. It is easy to understand the action of the acid, though it seems doubtful whether it should be desirable, but the sulphite was, and still is, so far as one's theoretical ideas go, entirely out of place. It is antagonistic to the persulphate, the two destroying each other. But Messrs. R. Namias and A. Baschieri have put the matter to the test of experiment. They find that the reaction between the persulphate and sulphite is complete in three or four days. It seems, therefore, that those who employ Bennett's formula are wasting the sulphite they add together with an equivalent amount of the persulphate, and that any gain in regularity of action is due to the weakness of the solution and, perhaps, to its excessive acidity.

Received.

Messrs. Wratten and Wainwright have just issued a new list of their plates, colour screens, and safelights for darkrooms. Many of these are unique in character and of special interest to scientific workers as well as photographers in general.

"The Agfa Handbook" for 1908 is to hand from Messrs. Zimmerman and Co. It is a list of the well-known "Agfa" manufactures with formulæ and advice as to their use. This firm are chiefly known among photographers as makers of developers, but they also make sensitive materials. The "Isolar" plates and films are worth special attention, as they have a film that is stained red between the sensitive film and its support to prevent halation.

Messrs. Newman and Guardia, of Shaftesbury Avenue, have issued a new catalogue that includes ordinary photographic requisites in addition to their own specialities. Their latest hand camera, the "Sibyl," is exceedingly compact when closed for the pocket. In addition to the catalogue proper, the volume includes some useful articles on subjects relating to hand camera work, and some fine examples of the results that have been obtained with "N. and G." cameras.

XUM

Solar Disturbances during February, 1908.

Our chart is constructed from the combined observations of Messrs. J. McHarg, A. A. Buss, and F. C. Dennett. The central meridian at noon on February 1, was 312° 8′.

Nos. 13, 15, and 16.—Repeated from last month's chart.

No. 17.—A minute pore seen only on February 1.

No. 18.—A group of three spotlets in area formerly occupied by No. 197, seen near the limb, 4th-5th.

No. 19.—An active group. On 4th one of its members 14,000 miles in diameter; on 5th like a portion of an ellipse, and on 6th, when last seen, only one pore.

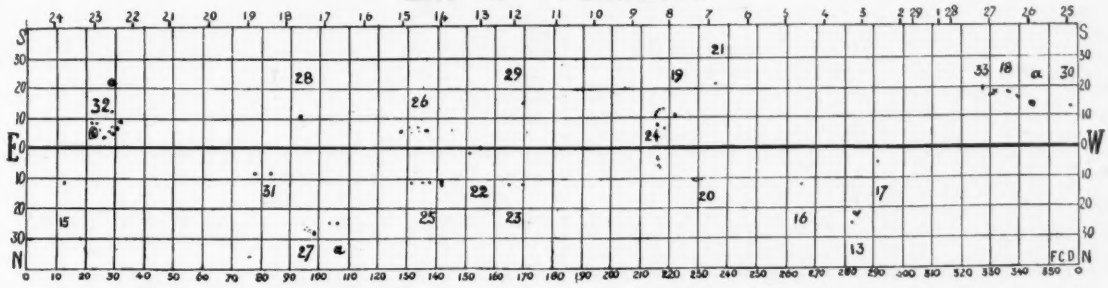
No. 20.—A protean group of four or five pores. 7th-10th.

No. 21.—A pore seen only 8th.

No. 22.—A pore 8th, two 30,000 miles apart 9th-12th, only one on 13th, when last seen.

No. 23.—A pair of pores 39,000 miles apart 8th-10th, but only the preceding one 11th-14th.

No. 24.—A pair of pores separated by 22,000 miles, the front one the smaller, 9th-10th.



No. 25.—A spot 11,000 miles in diameter, with pores extending 10° in its rear 10th-11th, 12th-16th one pore only closely behind the spot, which dwindled 17th-18th, when last seen.

No. 26.—A group of variable pores 67,000 miles in length. 12th-17th.

No. 27.—A spotlet, 12th-14th, having a few pores south-east when last seen.

No. 27*a*.—Pores 20,000 miles apart, seen only on 17th.

No. 28.—A spot in faculic area. 12th-16th.

No. 29.—A pore seen 17th-18th.

No. 30.—A tiny pore, 19th-21st.

No. 30*a*.—A spot 11,000 miles in diameter, bridged umbra on 26th and 27th, but in different directions, the spot dwindling. 21st-March 3.

No. 31.—A spot and pores, 21st-23rd.

No. 32.—A light auroral glow on 22nd, attracted attention on 23rd to the centre of the disc, which was occupied by faculæ. In this area by 24th a semi-elliptical group had developed, the following spot increasing to 35,000 miles in diameter by 29th, when last seen. The Astronomer Royal kindly notes that a slight magnetic disturbance lasting for two days intermittently, commenced about noon on 22nd.

No. 32*a*.—A pore only seen 24th.

No. 33.—A pair of pores 28,000 miles apart, 26th-27th, the leader visible until 28th.

The Average Age of Birds.

By Alex. Thurburn.

A great deal of information has been collected as to the highest ages which birds have been known to reach, as, for instance, in Mr. Gurney's paper in the *Ibis* for January, 1899, but the interesting question of the average age which birds attain does not appear to have ever been systematically investigated. It is evidently quite impossible to ascertain this average by direct observation. Not even a Darwin could compile a complete death register for the birds in a particular district, and, even if he could, it would be useless from his not knowing the ages at which the birds died. But if we leave immature birds out of consideration and confine ourselves to the question how long the birds that we see flying about in early spring will live on the average, a sufficiently near approximation could be reached indirectly, if it were known what proportion of these birds had been hatched during the previous year. No definite conclusions can be reached until the facts necessary to establish that ratio have been collected by trustworthy observers, but in the meantime it may be of interest to consider what results would be arrived at, supposing some particular ratio was so established. The temptation to test this is the greater as this ratio must, under given circumstances, lie within definite limits. Thus, in the case of those species which fulfil the following conditions, viz., first that they begin to breed when one year old and, second, that their numbers continue approximately the same, some at least of the young birds must survive till next spring and breed, otherwise the species would die out. On the other hand, the average of young birds, so surviving, out of those hatched by one pair, must be not greater than two, otherwise the number of the species would yearly increase, and so their average number for each pair of old birds must lie between 0 and 2. The most natural figure to take for the purpose of illustration is, therefore, 1, and in that case the average number of old birds surviving till early spring would for each pair necessarily be one also so that the number of the species may be stationary. In the following table the capital letters indicate the living birds and the figures annexed to them the year of hatching. The small letters indicate the birds that have died during the year that ends with the time just before a brood has been hatched. For greater precision the effect of the deaths being unequally distributed over the various months and the number of broods in the year would have to be taken into account, but limitations of space preclude the discussion of these and other minor details. This, however, is unnecessary in a table merely framed for the purpose of illustration, especially as the effect of

these details would be small, compared with that of the main factor, and they would, to a considerable extent, neutralise each other. It has, therefore, been assumed that the average age of birds hatched in 1901 and dying in the year preceding early spring of 1903 would be 1½ year, and so on. For the early spring of 1902 there have been taken four pairs which had been hatched in the preceding year, and one-half of these is assumed to have died before the early spring of 1903, while one of the offspring of each pair is assumed to have survived till that date :—

1902.—A 1, B 1, C 1, D 1, E 1, F 1, G 1, and H 1.

1903.—a 1, B 1, c 1, D 1, e 1, F 1, g 1, H 1, A 2, B 2, C 2, D 2.
a 1, c 1, e 1, and g 1 are assumed to have died at an average age of 1½ year for the reasons above stated. Only four of the birds hatched in 1902 are included, as immature birds are not dealt with.

1904.—b 1, D 1, f 1, H 1, a 2, B 2, c 2, D 2, A 3, B 3, C 3, D 3.
b 1 and f 1 would have died at an average age of 2½ years, and a 2 and c 2 at an average age of 1½ year.

1905.—d 1 would have died at the age of 3½ years, b 2 of 2½, and a 3 and c 3 of 1½.

Anyone interested may continue the table for himself, and it will be found that the progeny of E 1, F 1, G 1, and H 1 become extinct, and that, if the first set of birds, which were taken as all of the same age, be excepted, the average length of life would be 2½ years. Thus, A 3 died at the age of 1½, B 3 2½, C 3 1½, and D 3 4½. If it be thought that this result is unreliable, owing to the original birds having been taken as of the same age, or from the small number of pairs, it will be found that the error arising from the first circumstance is soon eliminated and, as to the second, that the result is the same, however large be the number of pairs taken.

If we now suppose that the observations made showed that the ratio just before the young were hatched was one of the last year's birds to three of the older ones, the average length of life would be found to be 4½ years. If the ratio were three young to one old, the average age would be 1⅛ year.

The tables would require to be modified for those species which do not commence breeding till later in life, and the results would show a higher average age for these.

It has been objected that the above table has been framed partly on deductive and not wholly on observational methods, but it would be folly to shut our eyes to the approximate knowledge which may thus be gleaned, when the fuller knowledge that might have been got from exclusively observational methods, if such had been feasible, is absolutely unattainable.

Answer to Correspondent.

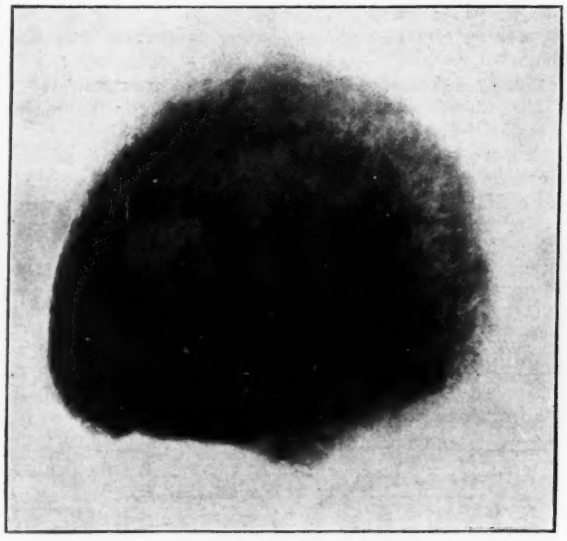
S. R. A. (*S. Tottenham*) will probably find the information he requires in the volume on Ants, Bees, and Wasps by Sir John Lubbock (Lord Avebury) in the *International Scientific Series*. *Formica fusca* is a black, and *Lasius flavus* a yellow ant. In addition to these, the red ant, or wood ant, *Formica rufa*, is a common specie in this country.

CORRESPONDENCE.

Pearl Finding.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

SIRS,—We are sending a photo which should prove of interest to your readers in view of the discussion which has recently taken place as to the possibility of finding pearls in



oysters by the use of X-rays. The illustration is a radiograph of an oyster in which a pearl has been placed, and which shows that it is quite impossible to find pearls in this way. It will be seen that the shell appears dark, which means that it is opaque to the rays.

Yours, etc.,

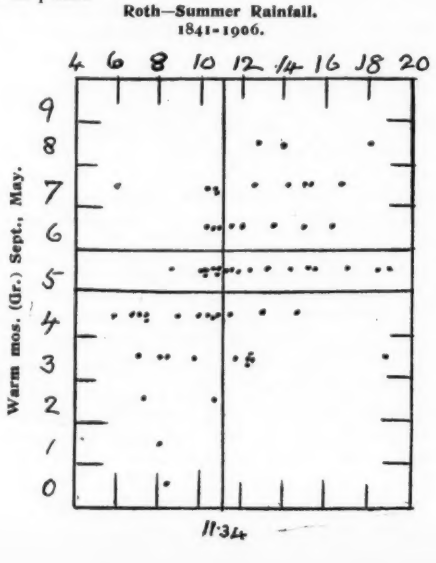
WILSON & BLACKALL.

London, W.C.

Forecasting Seasons.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

SIRS,—Most people seem to suppose that we have absolutely no light on coming weather beyond a day or two; say three days (for which forecasts are now regularly published in the *Times*). I think it is not so, and would submit a case in point.



There is reason to believe that the rainfall of Scotland and the amount of winter cold at Greenwich both show a definite relation to the sunspot cycle of 11 years, much rain and little cold going with maxima.

It seemed promising, then, to compare together these two things. The diagram shows one mode of comparison. Each dot, with reference to the *horizontal* scale, indicates the rainfall of one summer at Rothesay (in West Scotland), and with reference to the *vertical* scale, the number of warm months at Greenwich in the period September to May following (*i.e.*, in autumn, winter, and spring). By a "warm" month is meant one with mean temperature over the average.

A pretty distinct tendency is here shown; *much* summer rainfall, *many* warm months; *little* summer rainfall, *few* warm months.

Now, last summer at Rothesay was very wet, having 14.8 inches (the average being 11.34 inches). Looking at this point in the horizontal scale, and considering where the dot for the current months (September to May) is likely to go, I think we should have been safe in saying, at September 1 last, that there would probably be at least *five* warm months. And we have so far (March 12) had *five*, viz., September, October, November, December, and February. We might have one to three more.

Yours, etc., Alex. B. MacDowall.

(The correspondence between Mr. Henkel and Prof. F. del Marmol on the subject of "Is there a Central Sun?" is now closed.—Eds.*)*

NOTES.

ASTRONOMY.

By Charles P. Butler, A.R.C.Sc. (Lond.), F.R.P.S.

Presence of Water Vapour on Mars.

Professor Lowell has announced during the last few days that Mr. Slipher has succeeded in practically demonstrating the presence of water vapour in the atmosphere of Mars. On several plates specially prepared for this work so as to record wave-lengths up as far as the extreme red, the water vapour band *a* and the other prominent band near D have been photographed considerably stronger in the spectrum of Mars than in the spectrum of the moon at the same altitude. Much has hitherto been made by the opponents of the "habitability" of Mars as to these water vapour spectrum lines not showing up. Professor Lowell ascribes previous failures to the extreme difficulty of the investigation and also to the fact that until quite recently no photographic plates of sufficient rapidity and colour sensitiveness were available. Now these have been employed the confirmation is convincing.

Suspected New Satellite of Jupiter.

During the process of photographing the region of Jupiter for satellites VI. and VII., at the Royal Observatory, Greenwich, Mr. P. Melotte found on one of his plates an object which could not be recognised with certainty as having been previously observed. The plate was exposed in the 30-inch reflector on January 27, 1908, and appeared about the sixteenth magnitude. Since that date it has been re-observed on seven nights at Greenwich, and has also been photographed by Professor Max Wolf at Heidelberg on March 3. It is conjectured that, if not a minor planet, the new body may prove to be an eighth satellite of Jupiter.

Planetary Photography.

Professor Percival Lowell writes in *Nature* on the developments of planetary photography which have enabled the observers at Flagstaff, Arizona, to obtain such magnificent pictures of the planet Mars during the past year. The fundamental distinction between planetary and stellar photography is that with the former, definition, not illumination, is the primary point. To imprint upon the plate such delicate detail as the canal system of Mars requires a standard of definition so far beyond celestial photography in general as to constitute a class of work by itself. The chief disturber of the image is the atmosphere, and to minimise this the most rapid plates have to be employed. In addition an attempt was made to sort out the times of good or bad definition by taking a long series of exposures on the same plate at regular intervals of time.

A more serious cause of trouble is the non-achromatism of the objective, as the halos due to the secondary spectra slightly blur the outlines of the image. This has been reduced by employing coloured screens and isochromatic plates. Diminishing the aperture of the objective also sharpens the definition, but for photographic work this advantage is vetoed by the attendant loss of illumination. Following out these principles Mr. Lampland has gradually improved his results from 1905 to 1907, and in the latter year an expedition armed with duplicate apparatus was sent out to the Andes under the direction of Professor Todd. At Alianza, Chile, Mr. E. C. Slipher obtained about 10,000 images of the planet in the course of a couple of weeks, and, owing to the remarkable steadiness of the air and the high altitude of the planet, his plates show a wonderful amount of detail. Thus they show clearly the doubling of the Gihon and of the Euphrates, which had also been previously registered at Flagstaff. Canals and oases were photographed in profusion, as examples of which may be mentioned the two small oases in the Trivium. Similar agreement in the results obtained at the two stations is indicated by the drawings of Mr. Slipher and Professors Lowell and Lampland.

In preparation for the approaching opposition in 1909, Professor Lowell has devised an improved colour screen, and it is proposed to photograph a larger disc, the altitude being greater and the canal system being more developed owing to the advance of the Martian season.

Notwithstanding these great successes, however, it is insisted that the eye is still the most sensitive instrument for such researches on fine, faint detail, and the practice of always making careful comparison drawings will be also followed in future.

Dispersion of Light in Space.

Following up his work on this interesting subject ("Knowledge," March, 1908) M. Charles Nordmann gives the results he has obtained from a series of observations in Paris, Switzerland, and Algeria. The stars particularly studied were β Persei and λ Tauri, both of the Algol type of rapid variation, using for comparison stars δ Persei and γ Tauri respectively. In the case of β Persei it was found that the phases of the red screen image curve were in advance of the phases determined from the blue screen curve. The equivalent in time is such that the red rays of wave-length about λ 6,800 are received about 16 minutes ahead of the blue rays about λ 4,300, with a probable error of $\pm$ 3 minutes.

In the case of λ Tauri the red rays were still in advance, but the time displacement of the red and blue images was about three times as great as in β Persei, *i.e.*, about 40-60 minutes. On this reasoning it would appear that we have in these investigations a new method of determining stellar parallaxes; thus the parallax of λ Tauri would be about one-fourth that of β Persei, which, according to Pritchard, is $0''.0556$. Assuming these values as correct, the difference of velocity in space of the two extremities of the visible spectrum is of the order of 150 metres per second.—(*Comptes Rendus*, 146, p. 383, February 24, 1908.)

Calcium Vapour in Sunspots.

Mr. C. M. Olmsted has recently been investigating at the Solar Observatory, Mount Wilson, the occurrence of calcium bands in the spectra of sunspots and the laboratory conditions furnishing similar phenomena. Flutings of titanium have been detected by Hale and Adams, and of magnesium hydride by Fowler, but there were still several outstanding bands not accounted for by these substances, and it was in the course of some experimental work on the spectra of compounds that a banded structure was detected in the spectrum of the calcium arc burning in hydrogen. There are two main groups of bands; the stronger one near λ 6,385, the fainter running through the

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B group. All the bands are degraded towards the violet and are built up of complexly mixed series of lines. The bands appear when an arc formed between metallic calcium electrodes burns either in commercial hydrogen or in chemically pure gas, but do not seem to appear when the same electrodes burn in air. They also appear if wet cotton surrounds poles of calcium carbide in air. Tables of wave-lengths are given showing the agreement of the individual lines of these bands with the bands of the sunspot spectrum. Out of 84 spot lines in a certain region, λ 6,369-6,404, 62 are matched in the spectrum of calcium in hydrogen.—(*Astrophysical Journal*, vol. 27, p. 66, January, 1908.)

New Researches on Variable Stars.

M. Charles Nordmann has applied his coloured screen photometer to the study of the light curves of β Lyræ and δ Cephei, which stars represent the two extreme cases of stars of continuous variability, with results as follow :—

β Lyræ.—Using γ Lyræ as comparison star, the amplitude of the luminous variation (difference between the maximum and principal minimum) is very different for each of the coloured screens, being 0.66 magnitude for the red, and 1.34 magnitude for the blue screen. As seen through the red screen the two maxima are about equal, giving the appearance usually associated with the β Lyræ variation; the blue screen curve, however, is notably asymmetric as regards the two maxima, the first being about 0.3 magnitude greater than the second. From this it would appear that Lyræ emits a relatively greater proportion of red rays at principal minimum than at secondary minimum. These results are clearly indicated in the light curves given.

δ Cephei.—Using ζ Cephei as comparison star it is found that the amplitude of the light variation is notably augmented from 0.67 magnitude for the red to 1.16 magnitude for the blue. The blue screen curve presents in its descending portion a sharp inflexion which is only just perceptible on the red curve. M. Carl Wirtz has determined the photographic (probably only blue sensitive) variation of δ Cephei to be 1.2 magnitude, which is in good agreement with the value found by Nordmann.

For both β Lyræ and δ Cephei the epochs of maxima and minima agree with all colours with the Ephemeris times, as far as is possible to estimate, *i.e.*, within three or four hours. —(*Comptes Rendus*, 146, p. 518, March 9, 1908.)

BOTANY.

By G. MASSEE.

On the Occurrence of Colpomenia sinuosa in Britain.

MR. A. D. COTTON gives an account in the *Kew Bulletin* of *Colpomenia sinuosa*, Derbes. and Sol., a Brown Alga common in the warmer seas, and occurring abundantly in the Mediterranean, but until recently has not been recorded farther north than Cadiz. In 1906 it was recorded from the S.W. coast of Brittany, and soon afterwards from Cherbourg. Quite recently specimens have been collected at Torquay and Swanage, and the alga appears to have thoroughly established itself in the English Channel.

Colpomenia bears a general superficial resemblance to the English alga called *Leathesia difformis*, with which it has often been confused. The occurrence of this alga on our shores is a matter of some economic importance, as it has been shown to be the cause of considerable damage to the oyster industry. The alga is irregularly globose and more or less lobed or puckered; it is usually attached to rocks or other algæ. When young it is solid, but becomes hollow as it increases in size, and may attain to the dimensions of a tennis ball.

On the French coast the alga has acquired the habit of growing on young oysters in the oyster beds. On the receding of the tide the water escapes from the alga through certain perforations in the wall situated near the point of attachment to its support. On the return of the tide a certain amount of water again enters the hollow alga, but the whole of the air is not displaced, and if the alga is attached to anything sufficiently light it rises to the surface and floats, carrying its support along with it. By such means large quantities of young oysters were removed and lost; in fact, the loss was so great that attempts were made to recover them. The French cultivators of oysters have named the seaweed "ballons," and endeavoured to remove the danger by sweeping the oyster-beds with faggots of prickly branches, which ruptured the "ballons." It has been pointed out, however, that in this method the cure is worse than the disease, for although the floats are ruptured and rendered useless for the time being, the dissemination of the alga is favoured by the plants being torn into shreds and scattered wholesale by the tides, as every part of the plant bears reproductive bodies.

Phanerogamic Parasites.

The interaction between host and parasite has recently been studied by Dr. Fraysse, and a general summary is given in *Comp. Rend.* Plants that are most readily attacked by such parasites as *Lathræa Eyphrasia*, &c., which fix themselves by suckers, are those containing nodules of bacteria, mycorhiza, tubercles, &c. Suckers are sometimes pericyclic and sometimes endodermic in origin, and appear to be modified roots. The attack of a parasite usually causes the host to form a cambium zone or a layer of cork, for the purpose of isolating the infected area. Mucilage or gum is also often produced at the point attacked by the parasite. Some green parasites obtain both mineral food and carbon compounds from their host, as in the case of *Odontites*; others, as *Euphrasia*, absorb only carbon compounds. Parasites without chlorophyll obtain the whole of their food from the host-plant. In all instances the parasite exercises a selective power, and is capable of converting the food materials it obtains, by means of diastases, into compounds that it can assimilate. Carbon compounds appear to be mostly derived from glucose, and a special diastase is present in the parasite capable of the conversion of starch obtained from the host into glucose. The glucose thus obtained may be utilised at once, or it may be again converted by the parasite into starch for use at some future period. The suckers are provided with substances which protect the parasite from injurious matters contained in the host-plant.

The Haustorium of Olax scandens.

Dr. C. A. Barber, in describing the haustorium of *Santabun album*, made the discovery while collecting material, that certain Olacaceæ were also green root-parasites. An account of the parasitism of *Olax scandens*, profusely illustrated, is given in *Memoirs of the Department of Agriculture of India*. *O. scandens*, like many other root parasites, developes at first like an ordinary non-parasitic plant, living first on the food present in the endosperm, and later, in its swollen stem and tap-root. A copious development of root-hairs also enables it to obtain food from the soil. The comparative rarity of haustoria in the earlier stages of growth, the well developed root system, and abundant root-hairs even in old specimens, are considered as denoting incipient parasitism. Growing in thickets, *O. scandens* has an abundance of roots at hand to which to attach itself, and it readily avails itself of every opportunity, and is parasitic on a considerable number of different kinds of plants of widely separated affinities.

The haustorium is morphologically a complex structure, the vessels of the axial strand are uniform and narrow. In self-attached haustoria, that is, such as were attached to other *Olax* roots, fusion of the tissues of haustorium and root is the rule, and in such cases well marked sieve-tubes with callus-plates are present in such haustoria, the occurrence of which in the haustoria of green parasites has not been, it is believed, observed before.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

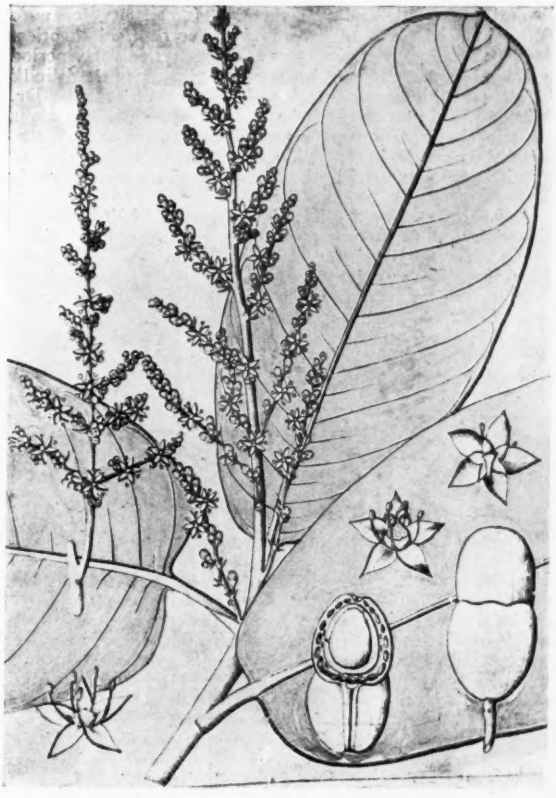
Nette Meal.

THE pulp known as "nette meal" is obtained from the fruit of the leguminous plant, *Parkia biglobosa*, Benth., and is highly prized as a food by the natives of tropical Africa.

It is formed within the ripening pod, and when the latter attains maturity is a dry and friable powder. From analyses recently made by MM. Goris and Crété the meal appears to contain about 5 per cent. of water, and about 1.5 per cent. of yellowish-red fat of the consistency of butter, and is rich in phosphates. It is quite free from starch, but is characterised by the extremely high proportion of sugars which it contains, about 25 per cent. being in the form of cane sugar and over 20 per cent. in the form of "invert" sugar, probably derived from the cane sugar. The remainder of the pulp consists, in the main, of a gum belonging to the class of substances known as pectins. If the plant can be made to flourish on the West Coast of Africa it will have a great industrial future as a source of sugar, the amount of which is much greater than is found in beetroot pulp, which contains not more than about 20 per cent.

The Indian Marking Nut.

The Indian tree, *Semecarpus anacardium*, produces a fruit which has long been used as a natural vegetable marking-ink, the characters made with the juice being remarkably permanent. The tree is also found in the West Indies and in North Australia, where the ripe fruit is used by the natives as food. The dried nut met with in commerce is a nearly black heart-shaped substance containing a white kernel covered with a brown pellicle round which is a black viscid juice. The native method of using the nut



for marking linen or cotton is to mix the juice with quicklime, whilst the dried juice is extensively employed in the manufacture of a black varnish. The juice itself and the fumes given off by it on roasting the nut have a curious irritant action upon the skin, causing a temporary eruption. Lewis was the first, in 1763, to call attention to the value of the juice as a marking fluid, and in his *Philosophico-Technicum* he gives details of his experiments with it. In 1859 Kindt described a method of preparing a marking-ink by extracting the nut with a mixture of alcohol and sulphuric ether and evaporating the extract to the required consistency. In specimens of the dried nut examined by the present writer the black juice surrounding the kernel had a characteristic aromatic odour, and produced a light brown stain, which gradually became darker on exposure to the air. A decoction of the crushed nuts in boiling water made alkaline with ammonia yielded a dark fluid, which produced dark brown stains on paper or linen. These stains were remarkably permanent, and very resistant to the action of reagents. They were not bleached by bromine, oxalic acid, or hydrochloric acid, and were rendered darker by alkalies. They were easily removable, however, by treatment with ether. The cashew nut (the fruit of *Anacardium occidentale*) has properties very similar to those of the marking nut, the juice producing a permanent dark stain upon linen, which does not darken, however, to the same extent on exposure to the air. The milky juice in the stem of the tree becomes rapidly oxidised and dries, forming a hard black film. It is, therefore, used as a varnish in the West Indies and the tropical parts of South America.

Arsenical Wall Paper and Moulds.

It has long been known that wall papers coloured with Scheele's green or other arsenical compounds may, under certain conditions, lead to arsenical poisoning, and the cause of this has usually been attributed to the dust given off when the wall became excessively dry. Professor Gosio, however, shows that the immediate cause is the decomposition of the arsenic compounds by certain mould-fungi, the action of which is promoted by the paste attaching the paper to the wall. The mould-fungi found to possess this specific property of converting the arsenic into a volatile organic compound having an odour of garlic are *Penicillium brevicaule*, *Aspergillus clavatus*, *A. fumigatus*, *A. glaucus*, *A. virens*, *Mucor mucedo*, and *A. candidus*, their activity in this respect corresponding with their order in the list. A certain amount of moisture is necessary for their acton; hence thoroughly dry wall papers cannot produce dangerous results. A certain degree of heat is also required, the *optimum* temperature being 68° to 77° F. The mould-fungi can only tolerate a limited amount of arsenic, and are poisoned when that limit is passed. They can, however, be gradually acclimatised to larger quantities. The volatile compound formed by the "arsenic moulds" in the presence of carbohydrates is an organic arsine having the composition $H—As<^{C_2H_5}_{C_2H_5}$. The moulds thus bring about the union of the arsenic with an alcoholic group. In fact, they are all capable of producing alcohol, though not all alcohol-producing organisms can decompose arsenic compounds, the property being strictly specific.

GEOLOGY.

By Edward A. Martin, F.G.S.

Where to Find Minerals.

An excellent little work has appeared under the title of "British Minerals and Where to Find Them," by J. Stephen Neil (London, Murby, 1908; 2s.). In the book are given 141 pages of "Mineral Localities," and these pages will be of great use to the wandering geologist, and perhaps save him many a fruitless search. This is followed by an alphabetical list of the majority of all recognised minerals, showing their form and habit, colour and lustre, and their mode of occurrence.

Dr. H. C. Sorby.

It was but a very short time ago that I recorded the reading of a masterly paper before the Geological Society by Dr. H. C. Sorby, and the promise of further contributions from his facile pen. Now it is with great regret that I have to

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record his decease, after a long and laborious life devoted to science. His connection as a Fellow of the Society dates back to the year 1850, there being few, if any, remaining whose record shows so lengthy a connection with the Society. In 1869 he was the recipient of the Wollaston Medal. He will be remembered principally for his labours in connection with the use of the microscope in petrography. He may, in fact, be regarded as the founder of this branch of the subject, although since his early days the microscope has come to be regarded as an absolute necessity to all students of lithology.

Women Geologists.

On April 1 a special meeting of the Geological Society of London will be held to consider the following resolution: "That the Council be requested to take the necessary steps, at an early date, in order to allow of the admission of women to full Fellowship of the Geological Society of London." Without commenting on the subject, I need scarcely remind our readers that many excellent papers have from time to time been presented by women geologists, whilst on eight occasions the Council of the Geological Society has recognised the value of their work by presenting them with the proceeds of the various funds at its disposal.

The River Wey.

Attention should be called to a recent paper by Mr. Henry Bury, modestly called "Notes on the River Wey." There is no doubt that our chalk streams furnish many important illustrations of river working, but they have been somewhat neglected for the more magnificent examples recorded in America. English geologists are beginning to take a leaf out of the book of their American brethren, and are proceeding to trace the changes which have occurred in the courses of our little rivers, and the influence they have had in shaping the scenery of the country around them. Mr. Bury divides that part of the River Wey which is within the Wealden area into six sections:—(1) The consequent river, cutting the chalk at Guildford; (2) the subsequent stream coming in from the east at Shalford; (3) the western subsequent stream parallel to the Hog's Back; (4) the continuation of the last westward (the Tilford River), rising at Selborne; and recieving many tributaries, including the Headley River, from between Blackdown and Hindhead; (5) the short obsequent section from Farnham to Tilford (the Waverley River); and (6) the portion above Farnham coming from Alton and beyond (the Farnham River). Mr. Bury first dealt with the relation of sections 6, 5, and 4 to the Blackwater. It is assumed that there was a consequent river coming down from Hindhead, flowing northwards along the Waverley River, and joined by the Farnham, Tilford, and Seale rivers. This seems to have been the original head of the Blackwater. But subsequently capture took place by section 3 of the Wey, with the result that the Tilford River passed into the Wey basin, and section 5 was thus beheaded. The development of an obsequent stream near the course of the last eventually tapped the Farnham River, but not the Seale. The paper also dealt with the palæolithic gravels of Farnham, and with the Farnham branch of the Wey.

Mammoth Research.

An expedition is being dispatched by the Russian Government to the north-east of Siberia, in order to investigate some discoveries which have recently been made of the mammoth in the province of Yakutsk. A large grant has been made to cover the cost, and some thoroughly competent men of science will take part in the expedition. It will be of interest if some of the remains will show an approach to the type of tusk which has come to light in America, in which the anterior extremity instead of turning outward only, also bends downward, and so makes the tusk of use in tearing away the undergrowth of low-growing plants.

Californian University Publications.

We have received the following Bulletins of the Department of Geology of the University of California: "Tertiary Fauna of the John Day Region of Oregon," by J. C. Merriam and W. J. Sinclair; and "Notes on Quaternary Felidæ from California," by John F. Bovard, with illustrations.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.Met.Soc.

The Dawn of Meteorology.

AT the meeting of the Royal Meteorological Society on March 11, Dr. G. Hellmann, the Director of the Royal Prussian Meteorological Institute, Berlin, delivered a lecture on "The Dawn of Meteorology." He began by saying that meteorology as a science is young, but as a branch of knowledge is very old, perhaps as old as mankind. Indeed, the beginnings of meteorology are to be found at the origin of human civilisation. In referring to weather proverbs, he pointed out that it would be wrong to imagine that the rich weather lore found in the Bible, especially in the book of Job, and in the poems of Homer and Hesiod—that is, in writings of the eighth century B.C.—originated then in Palestine or Greece. On the contrary, the familiarity of the people with the sayings and rules concerning the weather, revealed to us by these writings, show clearly that they must be considered as a primeval stock of the culture of that time. There is every reason to believe that the origin of much of modern weather lore can be traced to its Indo-Germanic source. Some of the tablets excavated from old Babylon, and which have been deciphered by English and German authorities, have been found to contain references to the weather. Dr. Hellmann said that the Greeks as far back as the fifth century B.C. were the first to make regular meteorological observations, some results of which are still preserved, and that their great capacity for pure science induced them to propound meteorological theories. After mentioning that the Greeks even at this early period used wind vanes, and referring to the "Tower of the Wind" at Athens, which was built in the first century B.C., Dr. Hellmann said that we find the first quantative observations—that is, the measurement of rain—in the first century A.D. These were made in Palestine, and the results of the observations are preserved in the Mishnah. Meteorology made but little progress among the Romans. The barbarous state of Europe after the fall of Occidental Empire was not adapted for the furthering of science, which was barely kept alive within the Christian Church. Yet the pursuit of meteorology never wholly ceased, for the fathers of the Church, writing commentaries on the work of the seven days, often took occasion, when dealing with the first day of the Mosaic Creation, to insert long elaborations on the atmosphere and its phenomena. The resuscitation of experimental science in the thirteenth century led to the development of regular meteorological observations in the fourteenth century. The earliest known record in this country was kept by the Rev. William Merle at Oxford from January, 1337, to January, 1344, the manuscript of which is preserved in the Bodleian Library.

Rainfall of the Thames District.

In *Symons's Meteorological Magazine* for March Dr. Mill has given a rainfall map for February, 1908, of that portion of England which may, without unduly straining the meaning of words, be termed the Thames District—that is to say, it is a map of the valley of the Thames from source to sea filled up so as to occupy a rectangle the size of the page. The groundwork of the map, which is printed in brown, shows by means of two tints the areas occupied by land more than 250 and more than 500 feet above sea-level, and in this way it brings the form of the country clearly before the eye. Brown dotted lines mark the boundaries of the drainage areas of the Thames and Lea above Teddington and Feilde's Weir respectively, and so define those parts of the country the rainfall of which is contributing to the water supply of London derived from surface sources. The black lines which cross the map are isohyetals, or lines of equal rainfall, and they are drawn from the rainfall at about 200 stations.

The map shows that the rain in February was very uniformly distributed. No station recorded so much as two inches, and none so little as half-an-inch. A large area in the upper Thames valley and a smaller area in the lower Thames valley had less than an inch of rain, while there were areas with more than one and a half inches along the

south-eastern side of the broad belt of hills which runs across the middle of the valley from south-west to north-east. The rainfall for the month was rather below the average, but it fell on a large number of days, most stations reporting rain on about 15.

We hope that Dr. Mill will see his way to continue this rainfall map month by month.

Rippling of Distant Lights.

The following letter has been received from Mr. W. D. Verschoyle, Tanrago, Ballisodare, Co. Sligo, with reference to the note on this subject which appeared in the March issue of "KNOWLEDGE":—

"Some years ago I noticed this effect whilst lying off Monte Video. It was very hot, and at the time I thought that the difference in temperature of air over sea and land would account for it. Later on, approaching the city of Seattle (Wash., U.S.A.) during winter, the air being very cold, I noticed the same rippling effect. The regularity of the waves and the temperature caused me to suspect other causes. Later, having charge of some operations where we had a small electrical lighting installation, at some distance from the power-house I noticed a rhythmical increase and decrease in brightness, in some lamps in one of the houses. It was very slight and would not have been noticed by most people. I went and had the dynamo stopped at once and examined the armature. This was not quite clean in three places where the brushes had rested during the day when the machine was not in use. I had the armature cleaned and then noticed that the rippling had disappeared. From this I was led to attribute the rippling to surging of the current caused by condition of armature, and I think that a long line is usually necessary to produce it, as it was only noticeable in the most distant lights."

ORNITHOLOGY.

By W. P. PYCRAFT, A.L.S., F.Z.S., M.B.O.U., &c.

Bird Protection.

THE Royal Society for the Protection of Birds desire us to draw the attention of the readers of "KNOWLEDGE" to the fact that they are offering a gold medal and a prize of 20 guineas for the best essay on Comparative Legislation for the Protection of Birds.

The essay must contain a survey of the legislation which has been made in foreign States on this subject, and therewith a comparison must be made with what has been done in Great Britain. The essays, which may be in English, French, or German, are not to contain less than 10,000 words, or more than 25,000. For further details as to the scope of this essay, and the conditions to be observed, we refer our readers to the Hon. Secretary of the Society, 3, Hanover Square, London.

Bittern in Yorkshire.

Mr. E. S. Steward, in "British Birds" for March, records the fact that on January 20 a boy returning to work at mid-day noticed a strange bird in a dry ditch outside the vicarage garden of Bishop Monkton, near Harrogate, which he captured. It proved to be a Bittern (*Botaurus stellaris*), and though apparently uninjured it died next day, presumably from starvation. A flight of four miles further would have carried it to ponds where an abundance of food and plenty of shelter could have been had! On the day of its capture, and on the day preceding, the wind was strong, and from the east.

Ospreys in Sligo.

In the *Zoologist* (January) Mr. W. J. Williams gives particulars of two immature Ospreys which were captured in Co. Sligo during November, 1907.

Night Heron in Co. Meath.

Mr. Williams also records, at the same time, the fact that an immature example of the Night Heron (*Nycticorax griseus*) was shot on Lord Darnley's estate in Co. Meath on November 21, 1907.

Sabine's Gull in the Firth of Forth.

Mr. W. Evans, in the Annals of Scottish Natural History, records the fact that an immature Sabine's Gull (*Xema sabini*) was identified on August 31, 1907.

Land-rail in Scotland in Winter.

In the *Field*, February 22, a short note will be found on the occurrence of a Land-rail on the outskirts of Edinburgh "about a fortnight ago." The bird was picked up dead, and had possibly died from starvation, though when seen by the recorder it was in an advanced stage of decomposition, thus making a post-mortem impossible.

The Flocking of Great Northern Divers.

Mr. A. W. Robinson, in the *Field*, March 21, gives a brief account of a flock of over forty Great Northern Divers (*Colymbus glacialis*), which were seen on Hoy Sound, Orkney, on March 6. From the usually solitary habits of these birds he suggests that they were gathering for migration. This is the more probable since during the same week of March three years ago he witnessed a similar flocking, though only eight participated therein on that occasion.

PHYSICS.

By PROFESSOR A. W. PORTER, B.Sc.

The Negative Charge of the Earth.

IT is well known that the surface of the ground in general possesses a negative charge. The evidence for this is the existence of a field of electric force stretching towards the ground, or, in other words, the electric potential of the atmosphere increases as we ascend. Professor J. J. Thomson in the first of a course of lectures at the Royal Institution has enunciated a theory to account for the production of this charge and to account also for its maintenance in spite of the fact that the atmosphere is electrically conducting owing to the ionisation produced in it by the action of the sun's rays and radium emanation from the soil.

The theory is based on the fact that when ions are present in a damp atmosphere and a sudden lowering of temperature occurs the moisture deposits more readily on the negative ions than on the positive. Hence each drop of rain in a falling cloud is usually negatively charged, and as it falls a field of electric force will extend between these falling negative charges and the positive ones which are left behind. Thus, although there must always be a slow return of the negative charge owing to the conductivity of the air, yet the amount on the ground is intermittently being maintained by the fall of rain. This explanation seems to be one with far-reaching applications to the whole theory of atmospheric electricity, thunderstorms, &c.

The energy of the field, as Professor Thomson pointed out, is, of course, produced at the expense of gravitational energy (but it must not be forgotten that the gravitational energy was itself produced at the expense of solar energy which evaporated the water, and there is no diminution of gravitational energy on the whole).

The Solidification of Helium.

The telegram from Kamerlingh Onnes to Professor Dewar announcing the solidification of helium has excited very general interest. Most interesting of all is the statement that the solid apparently sublimes—that is, passes, at ordinary pressure, into the state of vapour without passing through the liquid state. For some time the present writer has expected that this would be found to be so, and although the observation requires to be confirmed before it can finally be accepted as fact, the reason for this expectation may be mentioned here.

When the boiling points and melting points of the members of the argon group are plotted against their atomic weights the points lie on two almost straight curves which nearly meet at the points for argon. This is shown in the Figure.

Now let the curves be extended till they meet. If an element had an atomic weight corresponding to the melting point, for such an element the melting point and boiling

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point at atmospheric pressure would be the same. Such an element might be expected, therefore, when in the solid state to be in equilibrium either with its vapour or its liquid (or both); in other words, it would be at its triple point, the pressure at the triple point being atmospheric. Thus for all substances in the group of less atomic weight than this one the change of state would be presumably from gas to solid. There is considerable uncertainty in connection with this presumption because the form of the curves is not known beyond the portions drawn on the diagram. Analogy with the curves for other columns of elements in Mendeleeff's

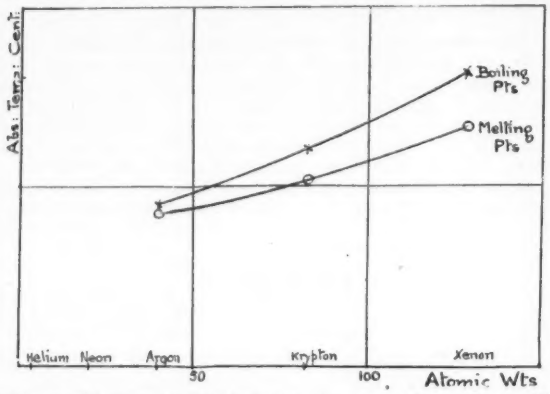

table would seem to indicate that the transition points will decrease very rapidly with decrease in atomic weight not far beyond the parts shown.

The temperature at which the solidification has taken place is not yet known. It should not be forgotten that in 1904 Olszewski considered that he had lowered the temperature to 1.7 Centigrade absolute without any change of state occurring. Whether or not this estimate is in conflict with Professor Kamerlingh Onnes' experiments will no doubt be made clear when a full account of these experiments is published.

ZOOLOGY.

By R. LYDEKKER.

A New Freshwater Medusa.

THE event of the month is the discovery in the turbid waters of the Yang-tsi-Kiang River in the heart of China of a small freshwater jelly-fish, or medusa, referred to the same genus as the one first observed in the tanks containing the giant waterlily in the London Botanic Gardens in 1888. As these Yang-tsi jelly-fishes have so long escaped notice, there is little doubt that species await discovery in other tropical or sub-tropical rivers. One, belonging to a genus apart from the Yang-tsi species is known to inhabit Lake Tanganyika; and if proper search be made in the Amazon and its tributaries there is little doubt that the original species of 1888 will be discovered in its native home.

The Gestation Period.

Our knowledge of the length of time different species of warm-blooded quadrupeds go with young has always been extremely imperfect, and in many respects is likely to remain so. A start towards putting our information on a more satisfactory basis has, however, been made in a recent issue of the German periodical long known as the *Zoologischer Garten*, where data are given for quite a large number of species. These serve to show that, as a rule, the larger members of any particular species have a longer gestation period than their smaller relatives, although there are many exceptions. The list is headed, as regards length of time, by the elephant; and it is also noteworthy that among hoofed animals the members of the odd-toed group, such as tapirs, horses, and zebras, have a longer gestation period than species of the same approximate size, such as antelopes, belonging to the even-toed group. The length of the incubation period in a large number of species of birds is likewise given in the same paper.

Golden Moles.

In Southern and South-Eastern Africa the place of the moles of Europe and Asia is taken by the golden moles, which derive their name from the brilliant play of iridescent metallic colours on their coats, which thus recall those of the sea-mouse. Although belonging to the same order of mammals as the moles proper, these golden moles indicate a very distinct family, characterised, among other features, by the triangular form of the crowns of their upper molar teeth. These moles have been known for fully a century and a half, and in some districts are comparatively common. Nevertheless, they are difficult to obtain, and a full knowledge of the group has, consequently, been very imperfect. This is exemplified by the fact that during 1907 Dr. R. Broom found himself in a position to describe no less than half-a-dozen new species and two new races of these curious animals; his first paper being published in the *Annals and Magazine of Natural History*, and his second in the *Transactions* of the South African Philosophical Society. It is to be regretted that for the typical species Dr. Broom retains the misleading name *Chrysochloris asiatica*. It is a positive absurdity that naturalists should be so tied down by adherence to rule that they consider themselves unable to reject a title like this, which should certainly be amended to *C. africana*.

Young Giraffes.

At the meeting of the Zoological Society held on March 3 the Secretary pointed out that young giraffes have relatively much shorter necks than their parents; the neck in the former being not longer than the fore-legs, which it largely exceeds in length in the latter. This, of course, is only what we should naturally expect to occur, but it, nevertheless, serves to bring the giraffe one step nearer the okapi.

Papers Read.

The inheritance of colour in domesticated pigeons, with special reference to reversion, formed the subject of a paper by Mr. R. Staples-Browne at the meeting of the Zoological Society on February 18, when Mr. O. Thomas also discoursed on mammals from the Mongolian highlands. On the same evening was read a paper by Mr. G. T. Bethune-Baker on "African and Papuan Butterflies." At the meeting on March 3 Mr. F. E. Beddard described the external characters of certain South American and Malagasy snakes; Dr. P. C. Mitchell read notes on a young giraffe; and Mr. R. I. Pocock described a new African monkey. All the papers were thus contributed by the Society's officers—an event probably unique.

REVIEWS OF BOOKS.

ASTRONOMY.

Liverpool Astronomical Society Annual Report for 1906-7.—Liverpool is one of the few places in this country that possesses an active astronomical society independent of the British Astronomical Association. The present report contains, in addition to minutes of the proceedings, abstracts of addresses and papers read during the year, and includes the President's address on Unsolved Problems in Astronomy, a *résumé* of recent advances in solar wave-length determinations, by Mr. George Higgs, whose portrait appears as frontispiece to the report; another "view-point" article, "The Sun," this time, by Mr. Whitmell, a prominent member of another independent society, that of Leeds, and several shorter papers, including two by Father Cortie, of Stonyhurst. The President (Mr. W. E. Plummer, of the Bidston Observatory) and the other officers and Council are to be congratulated on the continued vitality of their organisation.

BOTANY.

Elementary Botany; Studies in Plant Life, by J. Adams, M.A. (Fallon and Co., Ltd., Dublin).—This little book is one of the "School and College Series," and follows somewhat patriarchial lines and ideas. We are informed in the preface that some 16,000 scientific terms are used in botanical works, but that in the book under consideration such

terms have been used as sparingly as possible. Before we discovered this statement, we had come to the conclusion that the book consisted mainly of more or less accurate definitions of terms. Some of the statements made are rather startling, for instance: "If none of the ovules within the ovary are fertilised, of necessity, no fruit will result." A considerable amount of space is devoted to a statement of obvious facts unaccompanied by any explanation, thus: "In size, leaves exhibit great variety. The largest in this country are those of the butter bur, which may measure as much as eighteen inches across. The yew and flax, on the other hand, have quite small leaves." Why introduce the subject at all if nothing better than the above can be said about it? The book will prove of service to those desirous of learning the meaning of botanical terms, preparatory to entering on the study of systematic botany. The figures are numerous and generally well selected.

Eversley Gardens and Others, by Rose G. Kingsley (George Allen; 6s. net).—As a result of the wave of enthusiasm in matters relating to horticulture, numerous books dealing with gardening from various standpoints have appeared. Amongst such the work under consideration will undoubtedly take a high place. Although thoroughly practical throughout, the subject is treated in such a charming way that the reader is constantly lured on, wondering what shortcoming on the part of assistants in the work of building up a lovely garden from a wilderness will next be unfolded. Although obviously written by one who is in a position to indulge in the best and newest of floral products, yet each addition is the outcome of much study as to its suitability both from a cultural and æsthetic standpoint. There is much in the book that will prove of value alike to the practical gardener and to the possessor of a garden who desires to improve its general tone. The numerous illustrations are an important feature of the book.

METEOROLOGY.

Falmouth Observatory: Meteorological and Magnetical Tables and Reports for the Year 1906. Falmouth: 1907; 8vo., 21 pp.—The Falmouth Observatory is controlled by a committee of the Royal Cornwall Polytechnic Society, the secretary being Mr. Wilson Lloyd Fox. Mr. Edward Kitto is the superintendent of the Observatory. Grants for carrying on the work are made by the Meteorological Office, the Royal Society, and the British Association. The climate of Falmouth is very genial and equable, as will be seen from the following results:—

1906.	Temperature of the Air.		Relative Humidity.	Rain.	Hours of Sunshine	Temperature of the Sea
	Mean.	Daily Range.				
	°	°	%	ins.		°
January..	45.8	7.1	84	7.07	65.3	48.6
February	42.2	8.5	78	6.44	111.4	46.8
March ..	44.0	8.9	77	1.92	164.9	46.3
April ..	46.8	10.9	73	1.45	271.5	47.4
May ..	50.9	9.4	84	4.20	168.8	50.2
June ..	57.7	10.4	82	1.65	238.0	55.5
July ..	60 3	11.8	81	1.57	227.3	57.8
August ..	61.6	9.9	84	1.87	219.2	58.6
September	58.5	10.4	81	1.16	234.7	59.9
October..	53.4	8.9	88	4.54	113.4	57.3
November	48.3	7.0	84	4.53	61.6	52.8
December	43.3	7.6	81	4.68	59.3	49.9
Year ..	51.1	9.2	81	41.08	1935.4	52.6

The sunshine was 166 hours in excess of the average for the 25 years, 1881-1905.

The mean values of the magnetic elements for the year 1906 were as follows:—

Declination: 18° 5.3′ W.; Horizontal Force: 0.18790, C.G.S. Vertical Force: 0.43344, C.G.S.; Inclination, 66° 33.7′ N.

Meteorology in Mysore for 1906, by John Cook, M.A., F.R.S.E., Director of Meteorology in Mysore; xviii. and 122 pp., and 9 plates (Bangalore 1907; printed at the Government Press).—This is the fourteenth annual report, and contains the daily observations at four observatories, viz., Bangalore, Mysore, Hassan, and Chitaldrug for the year 1906. Mr. Cook has in this volume also given the mean daily values for the twelve years 1893-1904 of the various elements for each of the four observatories. It is stated that in accordance with the recent action of the Government of India, which has reduced the great majority of its second-class observatories to third-class ones, the Hassan and Chitaldrug Observatories will, for the future, be of this class, and will, therefore, record merely the 8 a.m. observations daily.

PHYSICS.

Technical Electricity, by Davidge and Hutchinson. Organised Science Series (London: University Tutorial Press, 1907; 4s. 6d.).—A successful attempt to span the gulf which divides pure theory and practical engineering. We are glad to see that the authors commence with electrostatics, as we are convinced that although electrostatic phenomena are not the ones which come before him chiefly, yet it is only by a thorough grasp of the elementary electrostatic phenomena that the behaviour of electricity in circuits can be properly understood. The book is laden with examples (many of which are worked out) and with excellent diagrams. We do not recall any book on practical electricity the examination of which has given us so much pleasure.

The Corpuscular Theory of Matter, by Professor J. J. Thomson (London: Constable, 1907; 7s. 6d. net).—Those who had the pleasure of listening to the lectures of which this book is an expansion at the Royal Institution will be glad of this fuller account of the fascinating subjects with which they deal. The book contains a description of the properties of electric corpuscles (or electrons) and their application to the explanation of some physical phenomena. The main characteristic of the book—as in everything that comes from Professor Thomson's pen—is that we are not presented with a dogmatic assertion as to what we must believe, but with speculative suggestions whose consequences are examined and whose faults are stated with the same frankness as their merits. We commend the book heartily to all who are interested in the rapid developments which are taking place in physics.

MISCELLANEOUS.

Religions, Ancient and Modern, consists of a series of small books, of which we have received four—"Animism," by E. Clodd; "Pantheism," by J. Allanson Picton; "Religions of Ancient China," by Prof. H. A. Giles; and "Religion of Ancient Greece," by Miss Jane Harrison (Archibald Constable, price 1s. net, each).—These form a most interesting compendium of religious thought in all ages, and should be widely read by those who wish to understand the significance of that great mystery, human religion.

The Metric System, by F. Mollwo Perkin (London: Whittaker, 1907; 1s. 6d. net).—This is an account of the metric system of weights, measures, and coinage, intended to assist those engaged in teaching chemistry, physics, engineering, or general elementary science. Worked examples are given. We wish the book good speed in its attempt to spread a knowledge of the simplifications of the decimal system. Is the author correct in saying that the standard metre is kept "in the Archives at Paris"? Borda's metre has been long superseded; the present standard is at the Bureau International.

BOOKS RECEIVED.

Functional Nerve Diseases. By A. T. SCHOFIELD, M.D. (London: Methuen, 1908, pp. 324; 7s. 6d. net.)

Remarkable Eclipses. By W. T. LYNN, B.A. (London: Bagster and Sons, 1908, ninth edition, pp. 59; 6d. net.)

OUR readers will be interested to hear that Messrs. A. and C. Black are re-issuing at a popular price the fourth edition of the late Miss Agnes M. Clerke's "History of Astronomy in the Nineteenth Century."

"KOH-I-NOOR" PENCILS.—Messrs. L. and C. Hardtmuth have submitted to us samples of their "Koh-i-noor" pencils, both the ordinary form for desk and draughtman's work, and those with different styles of point protectors for the pocket. Although they cover a great range of degrees of hardness, we find extreme smoothness in use to be characteristic of all of them.

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MICROSCOPY

Conducted by F. SHILLINGTON SCALES, B.A., F.R.M.S.

The Preparation of Microscopical Objects.

(*Continued from page* 69).

The microtome for celloidin sections must be a good one, and one of the Schanze type is best (see "KNOWLEDGE" for 1907, pp. 264 and 288). The knife must be heavy and long, and with a perfect edge, and it should be set obliquely so as to give as large a cutting surface (what is generally mis-described as a "slicing-cut") as possible. The edge of the object should be set parallel with the knife edge. After each cut the knife and section must be flooded with 70 per cent. alcohol, and if the feed is not automatic, the knife must be lifted clear of the object for each return stroke. Apathy recommends smearing the knife with vaseline. The sections can be transferred with a soft brush, spatula, or glass rod to a watch-glass full of 50, 70, or 95 per cent. alcohol as they are cut, according to subsequent requirements.

The object can, of course, be stained in bulk before embedding, but otherwise the staining is now to be proceeded with. This is a very important part of my subject, which I have left until afterwards, but I may say here that stains fall for the most part into two classes, those which are soluble in alcohol and those which are soluble in water. Sections for alcoholic stains can be stained at once direct from the watch-glass of 70 per cent. alcohol, but it is not advisable to transfer thin sections direct from strong alcohol to water, as they are liable to become badly distorted. Therefore for watery stains the dehydration process already alluded to must be reversed, and the sections put for three to five minutes into 50 per cent. and then into 35 per cent. alcohol or methylated spirit. Borax carmine and hæmatoxylin, made according to Delafield's formula, are typical watery stains; the former would require an immersion of half-an-hour to 12 or 24 hours, according to the section, as it is a very unpenetrating stain, whilst 10 to 30 minutes would probably suffice for the latter. Alcoholic eosin would require 30 seconds to a minute. Basic aniline dyes should be avoided for celloidin sections, as far as possible, as the celloidin itself stains rather markedly, though staining of the celloidin may be partly removed by slightly acid alcohol or ether. After staining with a watery stain the sections must be carefully dehydrated by a few minutes in graduated alcohols of 30, 50, and 70 per cent.

If acid alcohol has been used, as suggested above, it must be neutralised by floating the sections first into faintly alkaline 70 per cent. alcohol, made with a few drops of .01 per cent. sodium bicarbonate. This will also restore the blue colour of the hæmatoxylin stain, and make it more permanent. Too much soda will make the colour somewhat diffuse.

Whether the staining has been interpolated or not, the last stage is to transfer the sections from 70 per cent. alcohol to 95 per cent. for two to five minutes. Absolute alcohol must not be used as it dissolves celloidin. The sections are now cleared in carbol-xylol, cedar oil, creosote, or other clearing agent, for 15 to 30 minutes, and mounted in Canada balsam.

When sections are mounted in glycerine the dehydration is, of course, reversed, as for watery stains, and celloidin is quite transparent in this medium.

One mould can be used for several objects, and they can be cut and trimmed after they are set. The ends of the blocks can afterwards be softened in ether alcohol, and they can then be dipped in thick celloidin and fastened to the block, as described above, by pressing the two together, and then hardening in chloroform or 80 per cent. alcohol.

Sections can be fastened to the slide (which must be clean and dry) by pressing upon them with tissue paper, or the albumen method, so much used for serial sections and hereafter to be described under paraffin embedding, which is more suitable for serial sections, can be made use of. Another method is to flood the sections on the slide with 95 per cent. alcohol two or three times, drain off, follow on with a small amount of ether-alcohol, watch the sections carefully, and as soon as their edges begin to soften expose them to air for 30 seconds, and then immerse at once in 95 per cent. alcohol.

(*To be continued.*)

Royal Microscopical Society.

February 19.—Mr. A. N. Disney, M.A., B.Sc., in the chair.—Mr. J. E. Barnard exhibited and described an improved type of mercury vapour lamp for use with the microscope. It was exhibited applied to two microscopes, one with a screen giving absolutely monochromatic green light, the other without a screen giving a soft bluish light, which, owing to the absence of red rays, was an excellent illuminant for visual microscopic work. Mr. Gordon enquired if any short length waves of light, which might prove injurious to the user, were present. Mr. Barnard said this risk was practically *nil* as the glass tube absorbed nearly all the ultra-violet rays. A further safeguard in the case of glass tubes which were transparent to violet rays was to use a screen of a solution of sulphate of quinine. Mr. C. L. Curties exhibited a number of slides under microscopes illustrative of the life-history of some diptera. Some stereo-photo-micrographs by Mr. Wm. Dollman, of Adelaide, were exhibited. A paper by Mr. Nelson on "Eye-pieces for the Microscope" was taken as read. The Rev. Eustace Tozer read a paper giving the results of his observations, extending over a period of four years, on a rare protophyte. His paper was illustrated by lantern slides and living and mounted specimens under microscopes. Mr. Tozer also exhibited some slides of rotifers, stained, and mounted in balsam by a new process. Dr. Hebb read a paper by Mr. Fredk. Chapman on "Dimorphism in the Recent Foraminifer, *Alveolina boscii*." The paper was illustrated by photographs, and a slide showing the two forms was exhibited under a microscope. Dr. Hebb read a paper by Mr. Nelson on "*Biddulphia Mobiliensis*," in which the author describes some exceedingly minute secondary markings in the primary areolations of this diatom discovered by him. He concludes with some remarks on the advantage of the long tube microscope in such observations. Mr. C. L. Curties exhibited on the screen a number of lantern slides of various microscopic objects.

Quekett Microscopical Club.

February 21.—Annual Meeting. Professor E. A. Minchin, M.A. (Oxon.), was elected President. The retiring President, Mr. E. J. Spitta, F.R.A.S.,

F.R.M.S., delivered the annual Presidential Address, dealing with "The Photography of very Translucent Diatoms at High Magnifications." For the sake of obtaining sufficient contrast between object and background it was advised that all special diatoms to be photographed should be mounted in realgar, which has an index of visibility of 121 against the 9 of Canada balsam and the 22 of monobromide of naphthalin. A successful photographic method of getting rid of the "confusion-disc fog" around dot or pearl markings was described. A negative is made as usual on a fast plate, development being done with hydrokinone to secure maximum contrast. A positive is made by contact on a fast plate. From the positive is made a second negative and from this a second positive, both to be on slow "process" or "lantern" plates. Lantern slides showed the practical elimination of this trouble. Mr. W. Imboden, F.R.M.S., exhibited and described a *camera obscura* apparatus designed to facilitate the drawing of microscopical low-power objects, the image being projected, after reflection by a mirror, on to a drawing surface. Messrs. R. and J. Beck, Ltd., exhibited an immersion paraboloid for the illumination of bacteria, &c., on a dark ground with high powers, and Mr. W. B. Stokes showed a cheap silvered side reflector made by cutting in half a biconvex "reading-glass" lens of six inches focus and silvering one of the curved surfaces. The device seemed very efficient.

Microscopical Material.

By the kindness of Mr. W. E. Harvey, of Thornton Heath, I am able this month to offer to such of my readers as care to apply for it, some dogfish skin, cut into $\frac{5}{8}$-inch circles ready for mounting. They should be mounted dry and examined by reflected light, and make, as many of my readers know, very beautiful and curious objects. Unfortunately the supply is distinctly limited, so that I can only undertake to supply demands as far as the material goes, and in order of priority of application. Applications must be accompanied by a stamped addressed envelope and by the coupon to be found in the advertisement columns of this issue of "KNOWLEDGE."

Notes and Queries.

A. E. C. (*Kobe, Japan*).—The long tube, whether of a binocular or otherwise, is less suitable for photo-micrography than the short tube, owing to its comparative narrowness and length. Not only is there more trouble with reflection from the tube, but the use of low powers is also limited. Therefore a long tube binocular, used as a monocular, is less convenient than a short tube monocular. Moreover, nearly all objectives, unless specially ordered, are now corrected for the short or students' tube, so that the use of a long tube—with an eyepiece—is apt at times to prove inconvenient in unexpected ways. The binocular itself has many advantages, and is convenient and comfortable to use, but it is unsatisfactory with high powers, and should not be chosen in preference to a monocular where only the one instrument can be purchased. The interchangeable monocular and binocular bodies are very convenient for those who have only one microscope. I do not know anything of the special binocular prisms to which you refer. Living so far away as you do, you would be unable to inspect second-hand instruments for yourself, or to make alterations or exchanges if necessary, and I should, therefore, advise you to buy a new instrument and to put yourself into the hands of a first-rate firm, explaining what you want, and asking for an estimate. If you like to send it to me first, I shall be glad to do what I can to advise you, as I sympathise with your difficulties.

J. B. (*Coleraine*).—There is no way by which you can tell whether a dry slide of a diatom such as *Surirella gemma* is in optical contact with the cover-glass other than by using reflected light through a vertical illuminator, and transmitted light is of no use in this respect. You will have no difficulty in finding and focussing such a diatom, as its presence is quite evident. I think you will be interested in the book to which you refer, and learn from it much concerning the principles and management of the microscope, without reference to its application.

W. (*Liverpool*).—It is difficult to get satisfactory sections of moss capsules, and the ovule of Pinus is not easy. Very much depends on the fixing agent, and, perhaps, chromo-acetic acid is the most satisfactory, or, failing this, picro-acetic acid in 70 per cent. alcohol. If paraffin is used for embedding it should be hard, say 58° C. melting point. The capsules can be pricked with a needle whilst fresh, to allow the fixative to penetrate, and to enable the paraffin also to penetrate more easily. If paraffin sections prove impracticable it would be well to try celloidin, on the principles laid down in the microscopical columns of the present and the last issue of "KNOWLEDGE." The best stain is Delafield's hæmatoxylin, and counter-staining may be done with acid fuchsin. The above suggestions apply also to the other material you mention.

R. H. (*Leeds*).—A smaller parasite upon a larger one is quite an everyday occurrence, and you will probably remember Dean Swift's well-known lines:—

> "So, naturalists observe, a flea
> Has smaller fleas that on him prey,
> And these have smaller still to bite 'em;
> And so proceed *ad infinitum*."

Whether any particular parasite is addicted to the "Bookmite" (so-called, though it is really an insect; one of the Psocidæ) I cannot say, and as you give no description of the parasite you have found I cannot, of course, assist you in identifying it. You speak of it merely as an Acarus.

M. (*Dorset*).—Cover-glass staining for bacteria is very simple, and full particulars can be found in almost any medical book on clinical methods, such as Hutchison and Rainy's "Clinical Methods," published by Cassell and Co. at 10s. 6d. Broadly speaking, the general procedure is to make a very thin smear from sputum, or a culture, &c., upon a perfectly clean cover-glass and pass it two or three times rather rapidly through a flame, so as to fix the bacteria without scorching them, and then to proceed with the various staining methods, either in a watch-glass or by adding the stain direct upon the cover-glass, which, for this and all other processes, is held in a Cornet's forceps. There is no book on general microscopy to equal Carpenter's (last edition 1901). There are several newer works, but they deal with the microscope only, and do not touch its applications. There are also several good and recent books on methods of preparing objects.

N. L. G. (*Fulham*).—Seibert's No. 0 objective has a focal length of $1\frac{3}{4}$ inch and N.A. 0.13; No. II. of $\frac{1}{2}$ inch and N.A. 0.26; and No. V. $\frac{1}{6}$ inch and N.A. 0.9.

G. C. M. (*Leamington*).—The most convenient range of objectives for a beginner would be 1 inch and $\frac{1}{6}$ inch. To these it would be well to add a 2-inch, a $\frac{1}{3}$-inch, and a $\frac{1}{12}$ inch oil immersion of 1.0 N.A. or 1.25 N.A. if the purse permitted, but the first two will be the most generally useful, and after that the 2-inch. These should be obtained from a well-known English maker. If of Continental make the choice would be $1\frac{3}{4}$, $\frac{3}{4}$, $\frac{1}{3}$, $\frac{1}{6}$, and $\frac{1}{12}$, as these are more general sizes abroad.

N. N. (*Yorkshire*).—The two-guinea Histological sets can be obtained of Wm. Hume, Teviot Place, Edinburgh. They are fairly satisfactory, but would be only comprehensible to a medical student going through a serious laboratory course under a teacher. For an amateur, individual slides from Baker or Watson would be of much greater interest, and more easily understood.

New Catalogue.—Messrs. John Wheldon and Co., of 38, Great Queen Street, W.C., have just issued a catalogue of second-hand books and papers referring to microscopical science, including such subjects as diatoms, desmids, bacteria, micro-fungi, foraminifera, zoophytes, rotifera, &c., as well as works on the microscope itself. Messrs. Wheldon specialise in books on these subjects, and the catalogue contains many very interesting items.

[Communications and inquiries on Microscopical matters should be addressed to F. Shillington Scales, "Jersey," St. Barnabas Road, Cambridge. Correspondents are requested not to send specimens to be named.]

The Face of the Sky for April.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the Sun rises at 5.46 and sets at 6.23; on the 30th he rises at 4.44 and sets at 7.11. The equation of time is negligible on the 15th, hence this is a convenient day for the adjustment of sundials.

Sun-spots and faculæ may still be seen on the disc, and the spectroscope still shows a number of prominences on the limb.

The position of the Sun's axis, equator, and heliographic longitude of the centre of disc is shown in the following table:—

Date.	Axis inclined from N. point.	Centre of Disc S. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
April 5 ..	26° 25′W	6° 13′	188° 50′
,, 10 ..	26° 24′W	5° 53′	122° 50′
,, 15 ..	26° 11′W	5° 30′	56° 50′
,, 20 ..	25° 47′W	5° 4′	350° 47′
,, 25 ..	25° 11′W	4° 37′	284° 44′
,, 30 ..	24° 25′W	4° 7′	218° 40′

THE MOON:—

Date.	Phases.	H. M.
April 8..	☽ First Quarter	4 32 p.m.
,, 16..	○ Full Moon	4 55 p.m.
,, 23..	☾ Last Quarter	7 7 p.m.
,, 30..	● New Moon	3 33 p.m.
April 10..	Apogee	10 24 a.m.
,, 25..	Perigee	12 12 p.m.

OCCULTATION visible at Greenwich:—

Date.	Star's Name.	Magnitude.	Disappearance.		Reappearance.		Moon's Age.
			Mean Time.	Angle from N. point.	Mean Time.	Angle from N. point.	
			a. m.		a. m.		d. h.
April 10	η Cancri	5·5	0 44	72°	1 33	318°	9 20

THE PLANETS.—Mercury (April 1, R.A. 23h 5m; Dec. S. 8° 6′. April 30, R.A. 1h 59m; Dec. N. 10° 51′) is a morning star throughout the month, rising 30 min. before the Sun on the 1st, and 15 min. before on the 30th. The planet is within half a degree of Saturn on the 14th, but both are very near the Sun.

Venus (April 1, R.A. 3h 29m; Dec. N. 21° 11′. April 30, R.A. 5h 38m; Dec. N. 26° 52′) is an evening star setting about 10.45 p.m. throughout the month, and is very favourably placed for observation. She reaches her greatest elongation E. on the 26th, being then 45° 37′ from the Sun and near to β Tauri.

Mars (April 1, R.A. 3h 35m; Dec. N. 20° 4′. April 30, R.A. 4h 57m; Dec. N. 23° 37′) is situated in Taurus and sets soon after 10 p.m. His apparent diameter is getting smaller, being 4·3″ on the 15th. On the 4th Mars and Venus are in conjunction with the Moon and with each other within a few hours.

Jupiter (April 1, R.A. 8h 24m; Dec. N. 20° 9′. April 30, R.A. 8h 30m; Dec. N. 19° 47′) is still well placed for observation, crossing the meridian at 7 p.m. about the middle of the month. His position is quite near to Præsepe in Cancer on the 1st. He is in conjunction with the Moon on the 9th at 11 p.m. and is then 1° 21′ S. of the Moon.

The following table gives the satellite phenomena observable in this country between 7.30 p.m. and midnight:—

Date.	Satellite.	Phenomenon.	P.M.'s H. M.	Date.	Satellite.	Phenomenon.	P.M.'s H. M.	Date.	Satellite.	Phenomenon.	P.M.'s. H. M.
Apl.				Apl.				Apl.			
1	II.	Tr. I.	8 57	10	II.	Ec. R.	11 45	19	I.	Sh. E.	11 1
	II.	Sh. I.	11 22	11	I.	Oc. D.	8 14	20	I.	Ec. R.	8 11
	II.	Tr. E.	11 53		I.	Ec. R.	11 47		IV.	Oc. R.	10 23
2	I.	Oc. D.	11 53	12	I.	Tr. E.	7 51	24	III.	Tr. E.	8 27
3	II.	Ec. R.	9 10		IV.	Sh. I.	8 4		III.	Sh. I.	9 56
	I.	Tr. I.	9 10		I.	Sh. E.	9 6		II.	Oc. D.	11 29
	I.	Sh. I.	10 22	13	III.	Oc. D.	10 43	26	II.	Sh. I.	8 33
	I.	Tr. E.	11 30	17	II.	Oc D.	8 56		II.	Tr. E.	8 52
4	I.	Ec. R.	9 51		III.	Sh. E.	9 39		I.	Tr. I.	9 18
6	III.	Oc. R.	10 34	18	I.	Oc. D.	10 8		I.	Sh. I.	10 35
	III.	Ec. D.	11 53	19	I.	Sh. I.	8 41		II.	Sh. E.	11 29
8	II.	Tr. I.	11 28		II.	Sh. E.	8 51		I.	Tr. E.	11 39
10	I.	Tr. I.	11 2		I.	Tr. E.	9 44	27	I.	Ec. R.	10 7

"Oc. D." denotes the disappearance of the Satellite behind the disc, and "Oc. R." its reappearance; "Tr. I." the ingress of a transit across the disc and "Tr. E." its egress; "Sh. I." the ingress of a transit of the shadow across the disc, and "Sh. E." its egress; "Ec. D." denotes disappearance of Satellite by Eclipse, and "Ec. R." its reappearance.

Saturn (April 15, R.A. 0h 15m; Dec. S. 0° 37′) is too near the Sun for convenient observation at the beginning of the month, and only rises 45 min. before the Sun on the 30th.

Uranus (April 15, R.A. 19h 13m; Dec. S. 22° 46′) is low down in Sagittarius, rising at 2 a.m. in the S.E. about the middle of the month.

Neptune (April 15, R.A. 6h 53m; Dec. N. 22° 6′) is situated in Gemini, and sets about 1 a.m. on the 15th.

METEOR SHOWERS:—

Date.	Radiant.		Near to	Characteristics.
	R.A.	Dec.		
	h. m.			
Ap. 17-May 1	16 0	+47°	τ Herculis	Small, short.
,, 20-21 ..	17 24	+36°	π Herculis	Swift, bl. white.
,, 20-22 ..	18 4	+33°	κ Lyrae	Swift.
,, 30 ..	19 24	+59°	o Draconis	Rather slow.

Minima of Algol may be observed on the 14th at 12.27 p.m., and on the 17th at 9.16 p.m.

TELESCOPIC OBJECTS:—

DOUBLE STARS.—γ Virginis, XII.h 37m, S. 0° 54′, mags. 3, 3; separation, 5″·9. Binary system; both components are yellow, though one is of a deeper hue than the other. An eyepiece of a power of 30 or 40 is required on a 3-in. to effect separation.

π Boötis, XIV.h 36m, N. 16° 53′, mags. 4, 6; separation 6″. Requires a power of about 40.

ι Boötis, XIV.h 41m, N. 27° 30′, mags. 3, 6½; separation 2″·6. Very pretty double, with good colour contrast, the brighter component being yellow, the other blue green.

ε Boötis XIV.h 47m, N. 19° 31′, mags. 5, 7; separation 2″·4. Binary; one component being orange, the other purple.

CLUSTERS.—M 3 (*Canes Venatici*) XIII.h 38m, N. 28° 48′. This object, though really a globular cluster of myriads of small stars, appears more like a nebula in small telescopes. It is situated between Cor Caroli and Arcturus, but rather nearer the latter.